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Tanzania Food and Nutrition Journal

Volume II Number 1 – December 2006

ISSN 0856 0528

Tanzania Food and Nutrition Journal

Volume II Number 1 – December 2006

ISSN 0856 0528

Editors

Editorial Advisory Board

Published by Tanzania Food and Nutrition Centre
P.O.Box 977
Dar es salaam Tanzania

EDITORIAL

WHY TANZANIA SHOULD INVEST IN NUTRITION

The main nutrition problems affecting Tanzania are Protein Energy Malnutrition, Iron Deficiency Anaemia, Vitamin A Deficiency, and Iodine Deficiency. Low Birth Weight which is strongly related to nutrition is also a major problem. In addition, overweight, obesity and non-communicable diet related illnesses such as diabetes are emerging problems. Malnutrition affects ability of the body to fight diseases as it weakens immunity. As a result it increases the occurrence, severity, and duration of common childhood diseases, such as diarrhoea, acute respiratory infections, and measles. Again, Iodine Deficiency contributes to reduced cognitive performance of pupils and therefore wasting of educational resources.

Another nutrition problem which has an impact to the national development is short term hunger. When pupils face short-term hunger in school, their performance is reduced. On the other hand, stunted children tend to be enrolled later in school than well-nourished children. This late enrolment compounds the problems of intellectual impairment caused by nutritional deficits.

Increased attention to nutrition can enable agricultural sector to better meet its own needs in many ways. It can enhance the actioans directed towards poverty alleviation and nutrition impacts of agriculture and ensure greater support for agriculture as an important public good.

Moreover, partners in development need to realise the contribution of nutrition research in environmental conservation. For decades, nutrition research has been recognised to provide essential information on how environmental degradation can lead to major nutrition–related health problems such as malnutrition, infectious diseases and contamination.

These facts show that nutritional analyses, combined with an understanding of traditional systems and resources, can help identify the biological and socio-cultural components of solutions to dietary health problems associated with dietary change and adaptive strategies for the future.

Last but not least, nutrition and gender are interrelated. Gender inequality in access and control of resources not only is unfair to women and their children, but also constitutes bad economics. This results in the misallocation of scarce resources, increased health care costs, lowered productivity, and poor human development trends. Given the already susceptible situation of women and girls in Tanzania, efforts to improve the overall status of women should work hand in hand with efforts to improve the nutrition status of girls, adolescents, and adults.

It is from these and other perspectives that one can argue that good nutrition is central to improved income generation, poverty reduction, and more rapid development.

TANZANIA FOOD AND NUTRITION JOURNAL

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TANZANIA FOOD AND NUTRITION JOURNAL

Volume II Number 1 December 2006

CONTENTS

SMALL-SCALE PRODUCTION AND ACCEPTABILITY OF WHEAT-CASSAVA-SOY SHEETED NOODLES

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Running Title: Production of Sheeted Wheat-Cassava-Soy Noodles

ABSTRACT

Most utilization options for cassava and soybeans do not fit well in the life style of modern-day, urban-based societies partly because of the time it takes to prepare a meal. Homemade easy-to-cook cassava-based and/or soy-based products like noodles could offer a realistic utilization option for the two crops for such societies. A study was thus carried out that aimed at investigating the feasibility of using wheat-cassava-soy composite flours to produce acceptable noodles at a household level. In all formulations, soft-wheat flour (WF) constituted at least 50% by weight while the non-wheat ingredients {soy flour (SF), cassava flour (CF) or cassava starch (CS) – but not both} made up the balance. The study revealed that it is possible to produce noodles from all the tested formulations except those with 45% or more SF. It was also revealed that it is easier to work with CF than CS. All-wheat noodles were significantly more acceptable ($p<0.05$) than the other formulations in terms of colour, smell, taste, texture and general acceptability. Formulations with more than 20% CF or more than 10% SF were the less accepted while those with less than 80% WF produced objectionable noodles. It was concluded that it is possible to produce, at a household level, acceptable wheat-cassava-soy noodles provided the proportion of WF is above 80% while that of SF is below 10%. It was recommended that for the production of acceptable wheat-cassava-soy sheeted noodles, the proportion of SF in the formulations should be kept low as this ingredient has adverse effect on all the five tested sensory attributes, particularly smell. Also where possible, CF should be used in the formulations rather than CS.

Keywords: cassava, soybean, composite flours, noodles, formulations.

INTRODUCTION

Pasta and noodles are widely recognized as dough made by combining durum wheat flour (commonly known as semolina) with a liquid usually water or milk. In recent days, noodle formulations including non-wheat ingredients like sweet potato flour and tapioca starch have been reported (Limroongreungrat and Huang, 2002; Muhammad *et al.*, 1999). The dough is made into different shapes and sizes then dried and stored (Herbest, 1995; Dexter and Matsuo, 1980). When it is needed to prepare a certain dish, the noodles are simply boiled with salt and served with sauces, curry, etc. If kept dry, pasta and noodle products can be stored, without refrigeration, for several years without noticeable deterioration in either nutritional or organoleptic qualities. For this reason, among others, pasta and noodle products remain among the popular foods of modern-day societies (Vansteelandt and Delcour, 1998; Herbest, 1995).

Most of the utilization options involving cassava and soybeans do not fit well in the life style of modern-day urban-based societies (Ndunguru *et al.*, 1994). This is partly because of the enormous time required to prepare meals from these two crops and partly due to the lack of appropriate small-scale processing options to produce acceptable soy-based products. Incorporation of these two crops in food products that are popular to people of a busy life style, like noodles, is anticipated to offer a realistic utilization option that may suit them.

Cassava is cheap, readily available in most areas in the continent and is a high yielding crop. It does not require high rainfall, needs little inputs and care and is resistant to diseases (Nweke, 2003; Ndunguru *et al.*, 1994; Hahn, 1987). Cassava flour of acceptable organoleptic and nutritional quality is easily produced from dried cassava roots. In a similar way, soybeans grow well in tropical countries, like most African countries. Despite this fact, many people in Africa do not commonly utilize this crop in their diets. Soybeans contain an enormous amount of high quality protein, about 42 – 46% by weight, which is known to be superior to all proteins of plant origin (Gueguen and Cerletti, 199; Smith and Circle, 1972). Inclusion of cassava and soybean in noodle formulations was thus likely to serve three purposes: (i) to gradually increase the consumption of cassava and soybean by busy, modern-day, urban-based societies in Africa; (ii) to increase the income of cassava and soybean producing farmers by increasing the demand for the two crops; and (iii) to progressively reduce the problem of Protein-Energy Malnutrition (PEM) by developing nutritionally balanced noodle products. Therefore the main objective of this study was to investigate the feasibility of producing acceptable wheat-cassava-soy sheeted noodle products, at a household level.

METHODOLOGY

Preparation of materials

Acquisition of raw materials: Three raw materials were needed to produce the composite flours used in this study – wheat flour (soft wheat), fresh cassava roots, and soybeans. Wheat flour and other minor ingredients, like table salt and vegetable cooking oil, were obtained from a local supermarket (Pira's Cash and Carry, Morogoro, Tanzania). Fresh cassava roots and soybeans were obtained from the municipal market in Morogoro, Tanzania.

Preparation of cassava flour: Fresh cassava roots, as obtained from the market, were processed into cassava flour and cassava starch. For cassava flour, the roots were washed to remove sand and other impurities, peeled and split longitudinally into two halves to remove the mid rib. The rib-free halves were cut into several medium-sized pieces that were washed to remove any unwanted materials. The clean cassava pieces were then soaked in distilled water for 12 hours. After soaking, the pieces were washed again to remove mucilage and then chipped using a manually operated cassava chipper, to obtain thin chips. The chips so obtained were sun dried on drying trays and milled to get cassava flour. The steps involved in the preparation of cassava flour, cassava starch and soybean flour are summarized in Figure 1.

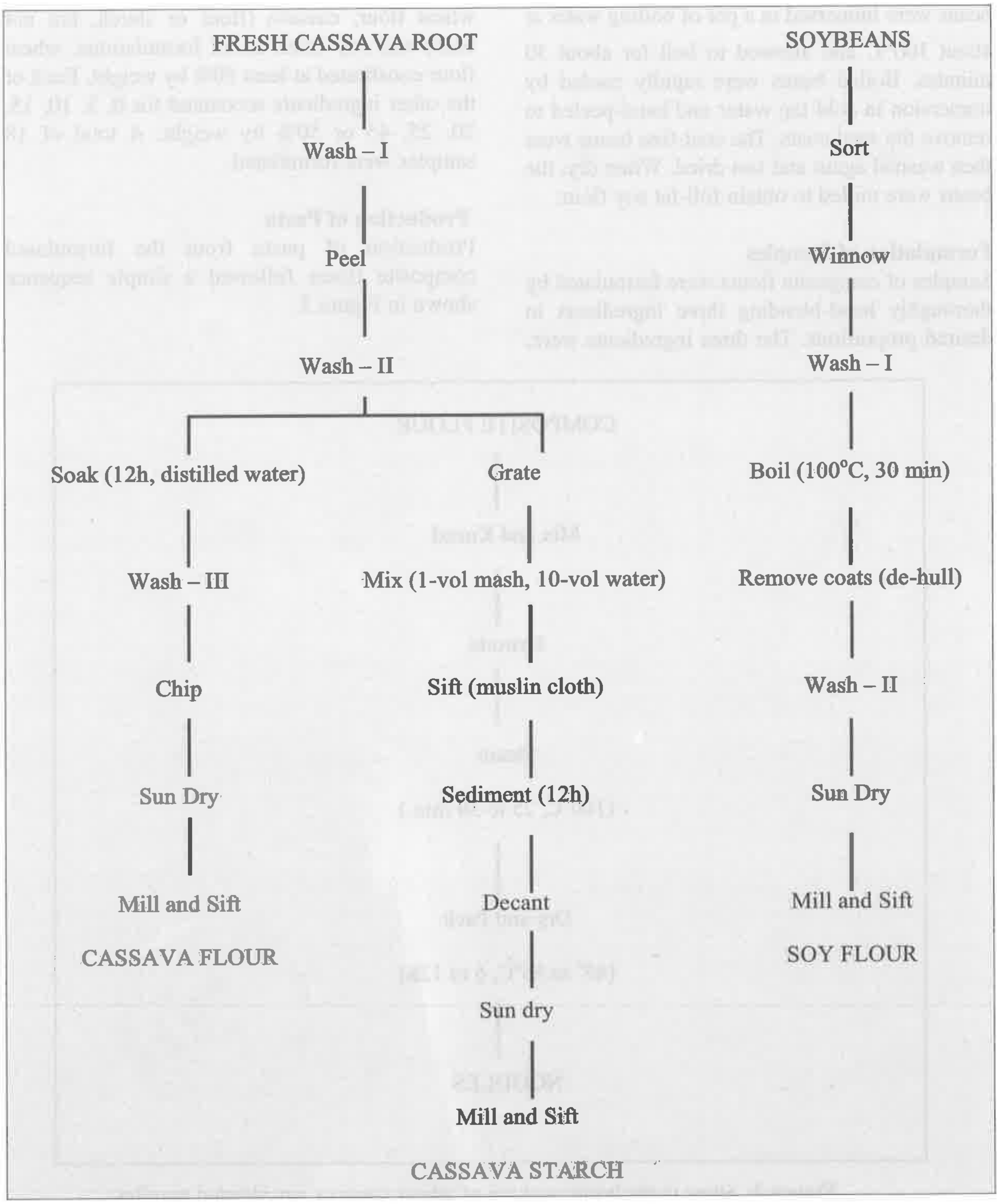

Figure 1: Steps for preparation of cassava flour, cassava starch and soy flour

Preparation of cassava starch: Clean, medium-sized cassava pieces (obtained as explained in the preceding section) were grated using a 3.73 kW (5 HP) engine-powered grater to obtain a fine cassava mash. The mash was thoroughly mixed with a large volume of distilled water (about 10 times the volume of the mash). The resulting slurry was sifted through a muslin cloth to remove cassava chunks and fibres. The chunk-free slurry was then rested for 12 hours to allow starch particles to settle, before decanting the water and sun drying the starch. Finally, the lumps of dry starch were milled to obtain clean cassava starch.

Preparation of soy flour: Dry soybeans, as obtained from the market, were sorted to remove unsound seeds, winnowed and washed. The beans were immersed in a pot of boiling water at about 100°C and allowed to boil for about 30 minutes. Boiled beans were rapidly cooled by immersion in cold tap water and hand-peeled to remove the seed coats. The coat-free beans were then washed again and sun dried. When dry, the beans were milled to obtain full-fat soy flour.

Formulation of Samples

Samples of composite flours were formulated by thoroughly hand-blending three ingredients in desired proportions. The three ingredients were; wheat flour, cassava (flour or starch, but not both) and soy flour. In all formulations, wheat flour constituted at least 50% by weight. Each of the other ingredients accounted for 0, 5, 10, 15, 20, 25, 45 or 50% by weight. A total of 18 samples were formulated.

Production of Pasta

Production of pasta from the formulated composite flours followed a simple sequence shown in Figure 2.

COMPOSITE FLOUR

Mix and Knead

Extrude

Steam

(100°C, 25 to 30 min.)

Dry and Pack

(45° to 55°C, 6 to 12h)

NOODLES

Figure 2: Steps in the home making of wheat cassava soy sheeted noodles

Mixing: Dough of about 31% moisture (wet basis) was produced manually by working a mixture of composite flour (500g) and distilled water (about 225ml). The dough was hand-kneaded until it was smooth and homogeneous.

Dough sheeting: The dough, as obtained above, was cut into six approximately equal pieces. Each piece was flattened and run through the widest setting of a simple, table-top, family-size, Italian noodle-making machine (Marcato–ATLAS, Noodle Maker Machine, Italy). The dough piece was repeatedly run through the noodle-making machine, progressively reducing the nip between rollers, until a sheet of desired thickness was obtained. The dough sheet was left for about 10 minutes before passing it through the cutting rollers of the same noodle-making machine to obtain long-run noodle strands (similar to spaghetti but flat).

Steaming: The noodle strands, fresh after cutting, were carefully placed in a small cooking pot and the pot was covered with a clean piece of muslin cloth. The noodle-containing small pot was subsequently placed in a bigger pot containing boiling water on a hot plate. The strands were then steamed for 25 – 30 minutes. The level of boiling water in the big pot was kept low to avoid the water splashing into the noodle-containing the small pot.

Drying and packaging: The steamed noodle strands were quickly separated from one another (to avoid sticking together), spread on the solar dryer trays and solar-dried for 6 -12 hours. The dry noodle strands were packaged in polyethylene bags ready for storage.

Sensory Evaluation

Sensory evaluation was carried out to assess the acceptability of the formulated noodle products. Fourteen of the 18 samples were tested. The other four samples (M, W, O and X) were outright rejected and were not included in sensory evaluation because they disintegrated completely into a slurry during cooking. Five sensory quality attributes were assessed: appearance, colour, texture, smell and general acceptability. A nine-point hedonic scale was used, where (1) stood for dislike extremely, (5) stood for neither like nor dislike and (9) stood for like extremely. The taste panel was constituted of 25 semi-trained panellists.

Laboratory Analysis

Samples of noodle products were analyzed for two important quality attributes of pasta and noodles – water absorption and cooking loss. Twenty grams of each sample were cooked for 5 minutes in 200 ml of boiling distilled water. Water absorption (the difference in weight between the wet cooked sample after draining the cooking water and the dry uncooked sample) was expressed as a percent of the weight of the dry uncooked sample. Similarly, cooking loss (the difference in weight between the dry uncooked sample and the dry sample after cooking, draining the cooking water and evaporating to dryness) was also expressed as a percent of the weight of dry uncooked sample.

Data Analysis

Data analysis for results of sensory evaluation tests was done using a statistical package [Statistical Analysis System – SAS version 6.12 (SAS Institute Inc., Cary NC. USA)]. Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) were employed for gathering inference on the data obtained.

RESULTS AND DISCUSSION

Noodle Production

It was possible to process most formulations into long-run noodle products (similar to spaghetti). However, for formulation X (WF:SF:CF:CS = 50:45:0:5) and formulation W (50:50:0:0), it was difficult to get a sound dough. The dough obtained was very stiff and lacked elasticity. The low quality of the dough obtained was attributed to the high proportion of soy flour incorporated in the formulations (45% and 50%, respectively). It has long been established that the quality of pasta and noodles depends to a large extent on the amount and quality of gluten present in the dough (Delcour *et al.*, 2000). It is also well known that semolina (not soft wheat flour) gives the best quality pasta and noodles. Although soy flour is rich in proteins, about 42% to 46%, this protein lacks viscoelasticity (Gueguen and Cerletti, 1994; Smith and Circle, 1972), which is characteristic of wheat gluten (Gueguen and Cerletti, 1994). Sample O (50% WF and 50% CS), was too sticky. For this sample, it was difficult to separate the strands after steaming but prior to drying. Also this sample was unique as it gave the lowest values for cooking loss and water absorption. In addition, this sample was among the four samples skipped in sensory evaluation.

Table 1: Water absorption and cooking loss for wheat-cassava-soy sheeted noodles.*,**

Sample					Sample weight (g)			Water absorption (%)	Cooking loss (%)
Code	Composition (%)*** WF	SF	CF	CS	Raw, uncooked	Cooked and drained	Cooked, drained, dried		
A	100	0	0	0	20.06	85.04	18.30	323.93	8.77
F	80	0	20	0	20.01	108.43	18.11	441.88	9.50
C	80	15	0	5	20.07	55.32	18.25	175.64	9.07
N	75	10	0	15	20.00	73.69	17.50	268.45	12.50
T	80	15	5	0	20.03	69.23	17.48	245.63	12.73
B	80	5	15	0	20.03	108.46	18.00	441.49	10.13
J	80	10	0	10	20.05	90.27	18.45	350.22	7.98
D	75	10	15	0	20.00	116.94	16.40	484.70	18.00
K	65	10	25	0	20.03	74.82	17.15	273.54	14.38
E	80	10	10	0	20.04	103.02	18.24	414.07	8.98
L	65	10	0	25	20.00	73.42	17.79	267.10	11.05
S	70	10	20	0	20.04	79.94	16.09	298.90	19.71
Z	80	20	0	0	20.00	61.63	16.29	208.15	18.55
R	70	10	0	20	20.03	96.02	15.57	379.38	22.27
M	50	5	0	45	20.07	141.65	17.17	605.78	14.45
W	50	50	0	0	20.07	84.50	17.51	321.03	12.76
O	50	0	0	50	20.00	60.81	19.18	204.05	4.10
X	50	45	0	5	20.07	86.77	16.47	332.34	17.94

* Entries are means of 2 replicates
** Samples were cooked in 200ml of boiling water for 5min.
*** WF = Wheat flour, SF = Soy flour, CF = Cassava flour, CS = Cassava starch

Cooking Loss

Cooking loss for the investigated samples ranged between 4.10% and 22.27% for samples O and R, respectively (Table 1). The cooking loss for the wheat-alone sample (A) was 8.77%, which compared favourably with a value of 5.58% to 8.48% reported by Limroongreungrat and Huang (2001) for pasta products made out of modified sweet potato flour supplemented with 15% to 30% defatted soy flour. Sample O had the lowest cooking loss of 4.10%, implying very strong binding of its particles. This sample had 50% cassava starch, and as observed by Güler *et al.* (2002), the changes in starch particles shape during drying have the greatest influence on pasta's cooking properties including levels of starch loss. On the other hand, sample R exhibited the highest cooking loss of 22.27%, suggesting weak binding of its particles. The cooking loss did not follow any clear pattern with regard to sample composition.

Water Absorption

Water absorption for the investigated samples, also known as cooking yield, ranged between 175.64% for sample C (80:15:0:5) and 605.78% for sample M (50:5:0:45). The wheat-alone sample had water absorption of 323.93%, which was reasonably close to the value of 335.68% to 346.75% reported by Limroongreungrat and Huang (2001) for the sweet potato/soy flour-based pasta. Heat-induced modifications on the starch ultrastructure have been reported to influence the water uptake of pasta products and other low water content food systems (Lo and Ramsden, 2000). The effect of cassava flour/starch and soy flour in the formulations, on water absorption, could not be confirmed conclusively.

Sensory Evaluation

A taste panel of 25 semi-trained panellists was used to evaluate five sensory attributes (appearance, colour, texture, smell and general acceptability) of the investigated samples. The evaluation was based on a nine-point hedonic scale, with (1) standing for dislike extremely and (9) standing for like extremely. A score of (5) was taken as a neutral point (neither like nor dislike), acting as a borderline between liking and disliking the product.

Table 2: Scores based on a nine-point hedonic scale for five sensory attributes (appearance, colour, texture, smell and general acceptability)*, ** for wheat-cassava-soy sheeted noodles.

Sample					Sensory Attribute				
Code	Composition (%)***				Appearance	Colour	Texture	Smell	General Acceptability
	WF	SF	CF	CS					
A	100	0	0	0	7.833^{a}	7.167^{a}	7.500^{a}	6.967^{a}	7.533^{a}
F	80	0	20	0	6.484^{bc}	6.613^{ab}	6.548^{b}	6.129^{ab}	6.677^{bc}
C	80	15	0	5	6.936^{ab}	6.613^{ab}	6.355^{b}	5.968^{b}	6.323^{bcd}
N	75	10	0	15	6.032^{bcd}	6.323^{ab}	6.161^{bc}	5.484^{bc}	5.774^{bcd}
T	80	15	5	0	5.226^{de}	5.613^{bcd}	5.677^{bcd}	5.710^{bc}	5.516^{cde}
B	80	5	15	0	5.645^{cde}	5.774^{bcd}	5.742^{bcd}	5.613^{bc}	5.774^{bcd}
J	80	10	0	10	6.000^{bcd}	6.226^{abc}	6.000^{bcd}	6.129^{ab}	6.258^{bcd}
D	75	10	15	0	4.742^{ef}	5.645^{bcd}	5.365^{de}	5.516^{bc}	5.452^{cde}
K	65	10	25	0	3.290^{g}	4.839^{d}	3.355^{f}	4.807^{c}	3.807^{f}
E	80	10	10	0	5.290^{de}	4.807^{d}	4.452^{e}	5.097^{bc}	5.000^{e}
L	65	10	0	25	4.677^{ef}	5.194^{cd}	4.516^{e}	5.323^{bc}	5.355^{e}
S	70	10	20	0	4.097^{g}	4.807^{d}	4.194^{ef}	5.581^{bc}	4.807^{e}
Z	80	20	0	0	5.742^{cde}	5.742^{bcd}	5.645^{bcd}	5.258^{bc}	6.161b^{cd}
R	70	10	0	20	5.388^{de}	6.032^{bc}	5.161^{cde}	5.839^{bc}	6.516^{bc}

* Entries are average scores for 25 untrained panelists

** Entries in the same column followed by different letters differ significantly ($p<0.05$)

*** WF = Wheat flour, SF = Soy flour, CF = Cassava flour, and CS = Cassava starch

Appearance: An all-wheat sample (A) was significantly superior ($p<0.05$) in terms of appearance than the rest. The only exception to this generalization was sample C (80:15:0:5) (Table 2). Ten of the 14 evaluated samples had acceptable appearance. The four samples with unacceptable appearance were D (75:10:15:0), L (65:10:0:25), S (70:10:20:0) and K (65:10:25:0) in that order of increasing unacceptability. The percentage of wheat flour in the formulation had a positive correlation with appearance ($r^2 = 0.703$). That is, increasing the proportion of wheat flour in the formulation improved the appearance of the product, and vice versa. For the non-wheat ingredients (soy flour, cassava flour and cassava starch), the correlation was poor, with r^2 values in the range 0.0013 to 0.3198. Nevertheless, there was a consistent trend of worsening appearance as the proportion of these non-wheat ingredients increased.

Colour: For this attribute, an all-wheat sample was not significantly different ($p>0.05$) from samples F (80:0:20:0), C (80:15:0:5), N (75:10:0:15) and J (80:10:0:10). The acceptability of pasta products, in terms of colour, increased as the proportion of wheat flour increased ($r^2 = 0.5261$) and decreased as the proportion of non-wheat ingredients increased. Three of the 14 evaluated samples had unacceptable colour; K (65:10:25:0), S (70:10:20:0) and E (80:10:10:0) in that order of decreasing acceptability.

Texture: The texture of an all-wheat sample was significantly better ($p<0.05$) than that of the other samples. Like the other attributes, texture also improved with increasing proportion of wheat flour in the formulation ($r^2 = 0.6702$). Similarly, the texture worsened with increasing proportion of the non-wheat ingredients. The texture of four samples was not acceptable; L (65:10:0:25), E (80:10:10:0), S (70:10:20:0) and K (65:10:25:0).

Smell: The smell of an all-wheat sample was generally superior to that of the other samples but not significantly different ($p>0.05$) from that of samples F (80:0:20:0) and J (80:10:0:10). Again, the smell improved with increasing proportion of wheat flour in the formulation ($r^2 = 0.5647$). Not surprisingly, the smell worsened with increasing proportion of the non-wheat ingredients, particularly soy flour. Only one sample had objectionable smell – K (65:10:25:0).

General acceptability: The general acceptability of an all-wheat sample was significantly superior ($p<0.05$) over the other samples. As expected, the general acceptability improved with increasing proportion of wheat flour in the formulation ($r^2 = 0.5261$). Also the general acceptability of the samples worsened with increasing proportion of the non-wheat ingredients. Only two of the 14 evaluated samples were generally unacceptable – S (70:10:20:0) and K (65:10:25:0) – with sample K being the most unacceptable.

CONCLUSIONS

This study revealed that it is feasible to produce acceptable wheat-cassava-soy sheeted noodle products by blending soft wheat flour with soy flour, cassava flour or cassava starch in the formulations. Inclusion of these non-wheat ingredients will undoubtedly increase the utilization of cassava and soybeans, particularly to the modern-day, urban-based societies. Also these non-wheat ingredients, particularly soy flour, will certainly improve the nutritional quality of the resulting noodle products. However, inclusion of these non-wheat ingredients should be done with care if the acceptability of the resulting noodle products is not to be compromised.

RECOMMENDATIONS

The proportion of wheat flour in the formulations should be kept high (not less than 80% w/w) as this has the strongest influence on all the five tested sensory attributes, as well as other non-sensory quality attributes of noodles like water absorption and cooking loss. Meanwhile, the proportion of soy flour in the formulations should be kept low as this ingredient has adverse effects on all the five tested sensory attributes, particularly smell. The presence of cassava starch in the formulation makes the production of noodles a lot more cumbersome than the other ingredients. Moreover, this ingredient has the minimum effect on all the tested quality attributes of pasta (both sensory and non-sensory attributes) compared to the other non-wheat ingredients. Thus this ingredient should be avoided in noodle formulations.

ACKNOWLEDGEMENTS

The authors express their appreciation to the Tanzania Agricultural Research Project – Phase II (TARP II-SUA) and Sokoine University of Agriculture (SUA) for funding the reported study. The assistance of the technical staff in the Department of Food Science and Technology, at SUA, is highly appreciated.

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FOOD PROCESSING SHOPS AS STIMULANTS TO DISSEMINATION OF CASSAVA PROCESSING TECHNOLOGIES IN RURAL AREAS OF TANZANIA

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ABSTRACT

Cassava-based small-scale agro-food enterprises have high potential as a means of achieving food security and poverty alleviation in rural areas. Also, the anticipated increase in the demand for good quality cassava food products would not be met if the current food processing capacity is not enhanced. The objective of this study was to investigate production, processing and utilization of cassava in Kibaha and Muheza districts so as to set out strategies for promotion of customer service oriented food processing shops as a realistic solution to enhancement of cassava utilization.

The study revealed that only 37% and 18.5% of farmers in Songabatini, Muheza and Magindu, Kibaha respectively were food secure with the rest being intermediate and food insecure. Furthermore, the study showed that it was difficult for farmers in rural areas to purchase and operate in a sustainable way the improved cassava processing machines which are sold at prices starting from TShs. 45,000 to TShs. 720,000. The promotion of rural-based cassava processing shops was therefore explored. This approach was important since most of the small-scale and subsistence farmers are unable to set up agro-food processing plants of their own. On the other hand, the majority can buy services from some progressive food-processing entrepreneurs in the villages. The opportunities and challenges facing cassava-based food-processing shops such as potential for manual operation and need for appropriateness and trainings are discussed.

It is concluded that there is a need of developing cassava processing industry in rural areas in a more innovative way so as to benefit the farmers and consumers living in the cassava growing areas. Also, it is recommended that for cassava processing shops to be sustainable they must be demand driven and therefore consumer preferences must be incorporated earlier on.

Keywords: cassava, processing, shops, enterprises, dissemination.

INTRODUCTION

Cassava is Africa's second most important staple food, after maize, in terms of calories consumed (Nweke, 2003). In Tanzania, cassava is produced for food and income generation and is widely produced in Eastern, Southern, Central and Lake agro-ecological zones (Kapinga *et al.,* 1995). The crop ranks high among food crops owing to its agronomical advantages compared to other crops. Cassava is very important in Tanzania, a country with a population of 34.5 million and is ranked second most important staple providing 409 calories per capita per day (Nweke, 2003). Based on its importance, there have been some initiatives to improve both agronomical aspects and processing of cassava under small-scale farming in Tanzania (Silayo *et al.,* 2003). The recent research initiatives in Tanzania have been concentrating more on the improvement of processing machines (Silayo *et al.,* 2003 and Nweke, 2003) but still a lot needs to be done on the improvement of the nutritional and hygienic quality, diversification and marketing of products. These aspects have generally been neglected in many countries in Africa (Essers, 1995).

Research on cassava processing is justified by many factors. For example, the level of carbohydrates in cassava is relatively high, which is an advantage in Africa because it makes cassava the cheapest source of food. Cassava is therefore one of the important crops in the efforts to combat malnutrition, especially when consumed with other dishes such as fish, meat, beans and a variety of vegetables (Ghosh *et. al.*, 1988). However, despite its importance, cassava post harvest aspects have continued to lack the attention they deserve mainly due to a common stigma in Africa that cassava is a low quality crop that is relegated to only being a famine crop (Nweke, 2003).

Among the important post harvest issues, improving cassava processing and promoting its consumption in both urban and rural areas is of paramount importance. Processing is a means by which a raw food material is biologically, chemically or physically treated and transformed into a slightly or totally different type of food (Fellows, 1997). It is therefore not surprising to note that most of our foods have to undergo processing before consumption. However, in order to process our foods we need to have efficient and appropriate equipment as well as use innovative approaches so as to simplify the work, which would otherwise be done entirely by using human manpower (UNIFEM, 1989). The use of processing shops seems to be one approach to processing cheaply the relatively good quality foods in rural areas of Tanzania. These processing shops are likely to allow even those in food insecure households to get access to good quality cassava products even without owning cassava processing machines. This is necessary since the poor are always at risk of food insecurity and markets always have a major impact on their ability to meet food needs (Mwiinga *et al.*, 2003). However, it is important to note that in order for the processing shops to be successful, there is a need to have appropriate technologies for each location depending on the local social and economic related factors. According to Mrema and Roselle (2002) most developing countries show a gradient in their post harvest capabilities with the technological level and scales varying widely both across and within countries.

This study was therefore aimed at establishing the current status of cassava farmers in Kibaha and Muheza districts to identify their constraints and potential areas for improvement. The specific objectives were to identify and evaluate the current production, processing and marketing strategies for cassava in the cassava growing areas. Also, the study was aimed at introducing simple processing equipment to suit the rural conditions.

METHODOLOGY

This study was carried out in Kibaha and Muheza districts during June 2001- July 2003. These areas were selected based on the high level of cassava production, processing and utilization. The study design involved three phases which involved surveying of cassava production and post harvest handling, introduction of cassava post harvest handling and processing technologies and dissemination of the technologies to other non-project areas.

Survey on Cassava Processing Capabilities

A survey was conducted in Magindu and Songabatini villages in Kibaha and Muheza districts respectively to reveal the status of cassava processing. Primary data was collected from farmers in these areas regarding the entire chain of cassava production which included production, post harvest handling, processing and marketing of cassava-based products. In addition, literature search was conducted on trends in cassava production, area of land use and cassava processing in the study areas.

Introduction of Simple Processing Equipment

Based on the results of the survey carried out in the study area, arrangements were made to acquire cassava-processing machines suitable for the surveyed villages. In total three designs of cassava processing machines were acquired and developed to suit the requirements of the farmers in the area. These machines included manual chippers, engine powered (3 -5 HP) chippers and engine powered (5 HP) graters. Acquisition of these machines was followed by on-station and field trials to establish their performance and scope for improvement. This was carried out in close collaboration with the contact farmers in Magindu (Mizuguni A hamlet) and Songabatini (Palatembo hamlet). The modification carried out in these machines was mainly aimed at improving the performance (throughput and efficiency), ergonomics and general acceptability. Based on these modifications two sets of machines comprising of 2 manual chippers, 2 power graters and 2 power chippers were stationed in each of the two participating villages for the extended field trials under the actual village- based cassava processing conditions.

Introduction of Food-based Cassava Processing Technologies

This involved introduction of improved technologies for processing cassava. The aim was to improve both nutritional and hygienic quality of the existing and new products so as to increase value and therefore expand their marketing boundaries that at the time of the study were confined within the villages.

Dissemination of the Developed Technologies

Methods used to disseminate the developed technologies involved giving emphasis to farmers to work in groups so as to make it easier for them to acquire food-processing machines. However, individual farmers were also encouraged to participate in the processing activities. In addition, the use of leaflets, booklets, newspapers, radio and television was encouraged for a wider dissemination of the technologies.

RESULTS AND DISCUSSION

Survey

The survey revealed that low prices of cassava are normally offered when there is a surplus or high maize harvest with the exception of the fasting month. Under such a situation little or no crop is processed and some farmers opt to leave their cassava in the field as a means of storage and sell their crop only when the price is increased. Also, cassava is only sold fresh during this period. It is only a handful of farmers who sell processed cassava in the form of traditionally processed products (*Makopa*) or fried kebabs (*Vibabu*) as shown in Table 1. The study also revealed that although the majority of people in rural areas do consume cassava *(ugali)*, the sale of cassava flour is not common. This implies that the majority of the households are involved in the preparation of their own flour. It is likely that the lack of trade in cassava flour is mainly due to poor processing technologies and perishability especially when moisture content is high.

Table 1: Common Practices Involved in Storage and the Type of Procssed Products Traded in the Surveyed Villages

Post harvest Handling practices	Kibaha			Muheza		
	Food Secure	Intermediate Food Secure	Food Insecure	Food Secure	Intermediate Food Secure	Food Insecure
Storage of fresh cassava	In field	In field	In field	In field	In field	In field
Common type of locally traded cassava products	*Makopa*	*Makopa*	-	*Makopa* *Vibabu*	*Makopa* *Vibabu*	-

Technology Development

The study found out that involving the stakeholders especially farmers right from the beginning is likely to lead up to development of appropriate technologies for the local environment. Also, it was revealed that developing any technology tends to be associated with costs that normally the end users have to bear. Under this study, cassava-processing machines were developed with close consideration on the prices of such machinery, as this could become a stumbling block to their wider dissemination. However, all of these machines had efficiencies and throughputs, which were relatively higher than the rudimentary traditional methods as indicated in Table 2 and Table 3.

Table 2: Comparison of the Outputs (Means) from Different Cassava Chipping Machines Suitable for a Household and Village-based Industry

Type of equipment	Throughput (Kg/h)	Daily throughput* (Kg/day)	Potential for local Fabrication
Hand held knife chipping for small chunks (Traditional)	11[a]	110[a]	Yes (traditional)
Pedestal type manual chipper	270[b]	2700[b]	Yes
Engine powered chipper	850[c]	8500[c]	Yes (except an engine)

*Calculated based on a 10-hour working day.

Table 3: Comparison of the Outputs (Means) from Different Cassava Grating Machines Suitable for a Household and Village-based Industry

Type of equipment	Throughput (Kg/h)	Daily throughput* (Kg/day)	Potential for local Fabrication
Rasping iron sheet (Traditional -- hand operation)	4	40	Yes (traditional)
Engine powered grater	600	6000	Yes (except an engine)

*Calculated based on a 10 hours working day.

In order to facilitate a smooth dissemination of cassava processing machines, two categories of machines were promoted. These included low throughput, low cost and manually operated machines and high throughput, high cost, power operated machines. The manually operated machines were characterized by low throughput and relatively low costs of TShs. 45,000 and TShs. 60,000 whereas the power operated machines were characterized by high throughputs and outturn with their price being TShs. 120,000 and TShs. 720,000. However, it was observed that even at a price tag of TShs. 45,000 and TShs. 60,000 for the table mounted and wooden legged chippers respectively, most of the households in the study areas could not afford them especially those in the intermediate food secure and food insecure ranks. This situation indicates that there is a lot to be done if countries like Tanzania have to mechanize its agriculture in order to sustain itself as suggested by Mrema and Rolle (2002) bearing in mind the indication of food security as obtained from the villages (Table 4).

Table 4: Food Security (%) Ranking in Palatembo and Magindu Villages in Muheza and Kibaha District Respectively

Village	Food security group distribution (%)		
	Food Secure	Intermediate	Food Insecure
Palatembo	37.00	35.00	28.00
Magindu	18.50	54.00	27.50

Possible Role of Processing Shops in Promoting Post-harvest Issues

This study found out that although the primary goal of the project was to enhance food security and income generation, if these technologies have to benefit a wider population reaching out to other groups is necessary. Such groups include farmers groups, village-based youths groups, women groups and co-operative societies such as Savings and Credit Cooperative Societies (SACCOS) but most importantly progressive entrepreneurs within or from the neighbouring villages who can invest in cassava processing sector.

One way of reaching such groups will be to initiate cassava-processing shops. These shops will be operated like the now famous computer internet shops, giving access to processing to even those farmers who could not afford a processing machine. Under the suggested system, farmers will be paying a fee for the service they receive, which could be in cash or in-kind based on the agreed amount of the product such as flour. These shops will provide farmers with different options in processing their cassava (Figure 1) thus stimulating processing activities.

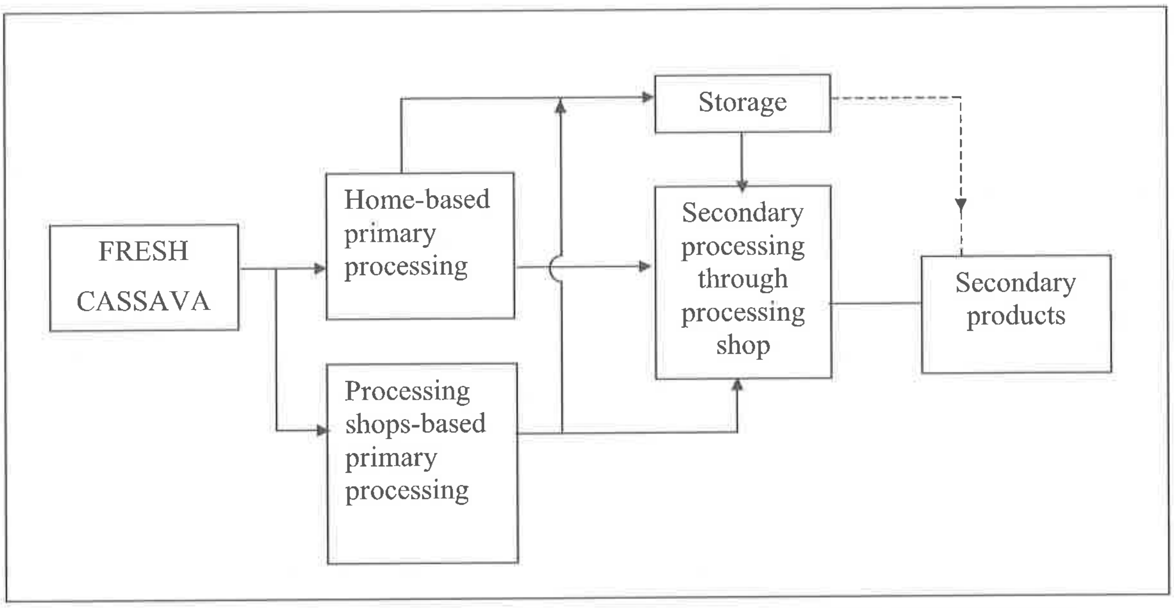

Figure 1: Various Options for Processing Cassava Products Based on the Introduction of Processing Shops in Rural Areas

The modalities of these shops will depend on the level of processing required i.e. primary processing (peeling, chipping, gratings, etc.) only or primary processing and secondary processing (i.e. to include flour milling). Such shops should work on principles similar to those employed in successful grain milling shops for crops such as maize, rice, sorghum, and wheat and may be operated individually or by a group.

Opportunities of Processing Shops

The cassava processing shops have a potential of using simple equipment coupled with simple technologies as opposed to large factories, which rely on complex machines. Also, they have a potential of being started using manual and simple methods and equipment then being upgraded as the enterprises grow (Mrema & Roselle, 2002). This is added advantage particularly for the processing shops, which are in rural areas, where the level of expertise is low. In addition, through promotion of cassava processing shops, it is possible for the locals in particular areas such as farmers, traders, etc., to start entrepreneurship activities based on their locally available cassava as raw materials. These enterprises based on indigenous knowledge have a potential of growing up to become an important tool for development within the locality. It is clear that if given the required support and motivation, these cassava-processing shops have the capability of developing to meet the local demand of processed food. Cassava processing shops could also play a major role in the issue of primary processing of food stuff and pre-preparation, then selling the semi-prepared food to larger companies which are few and concentrated in the urban areas. In this case the small scale and large-scale factories will co-exist in harmony. Also, although job creation is not one of the main goals of many processing shops, this tends to happen as the enterprises grow. The processing shops offer job opportunities to the local communities, which eventually help to reverse migration to the urban areas, especially by the youths. Moreover, since agro-food processing shops are labour intensive, they tend to attract the disadvantageous group of women who are the majority in developing countries like Tanzania. It is therefore possible to start numerous food processing centres through these processing shops thus providing employment to many individuals who would otherwise be unemployed.

Expected Challenges

The study has revealed that there are a number of challenges which are worthy tackling if cassava processing shops have to develop in rural areas. For example, there is a need to continue developing and adapting appropriate cassava-processing equipment for use in rural areas. Part of this is already being carried out but more needs to be done particularly on the dissemination aspects. Another challenge is in the aspect of training. If this initiative has to succeed, there is a need to provide training on cassava processing techniques, equipment handling, maintenance and repairs. Also as far as training is concerned, arrangements need to be put in place to provide backup services especially in food quality and safety aspects. Also, there is a need of working carefully on the issue of volume versus economic operation of small scale processing plants. This will ensure that appropriate sizes of the machines are acquired depending on the available cassava crop and the projected future yields. This will prevent the underutilization of machinery, which is always a problem in small-scale rural-based food processing plants.

CONCLUSIONS

Many farmers in the developing world, including Tanzania, have not been able to move out of the subsistence level. This has been partly due to the fact that they lack means of processing their produce, which eventually ends up being wasted. This study has clearly shown that cassava processing is becoming very dynamic and has seen a number of innovations and equipment development. Also, there have been some regular and beneficial changes in the processing technology itself and the hardware. The level of the technological capabilities has therefore been higher which calls for developing industry in a more innovative way if it has to benefit the farmers and those living in the cassava growing areas. Under these conditions it is becoming more evident that there is a need of promoting cassava-processing activities in a well-organized approach such as that of processing shops. Through development of cassava processing shops in rural areas, it will be possible for the farmers to process and market their products in substantial amounts and thus increase their income therefore breaking away from the poverty circle.

RECOMMENDATIONS

It is recommended that in future, research on processing and value addition of cassava, should involve potential rural-based entrepreneurs. Again, for these shops to be sustainable they must be demand-driven and therefore consumer preferences must be incorporated earlier on. It is extremely important to investigate the success of maize and rice milling shops and incorporating their success in the promotion of cassava processing shops.

ACKNOWLEDGEMENTS

This article is an output from TARP-II SUA research project. Authors are grateful to the Royal Government of Norway and the Government of the United Republic of Tanzania for the financial support, which enabled this study to be carried out. The active participation of farmers and Village Extension Officers (VEOs) from Magindu and Songabatini villages in the research activities is highly appreciated.

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VALIDATION OF PARTICIPARTORY NUTRITIONAL STATUS ASSESSMENT PROCEDURE IN MAASAI AND BATEMI COMMUNITIES AND RELIABILITY OF ANTHROPOMETRIC MEASUREMENTS

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ABSTRACT

A validation study was conducted in the Maasai and Batemi communities of Arusha, Tanzania between December 1996 and January 1997. The aim of this study was to compare a participatory nutritional status assessment procedure carried out by community members, with assessment completed by a professional. The study determined prevalence of under-nutrition among preschool children (12-71 months) and non-pregnant women (15-50 years of age) in the communities and tested the reliability of anthropometric measurements. The prevalence of under-nutrition was similar for the two data sets, and reliability of anthropometric measurements was found to be good. However, an exception was observed on the mid-upper-arm circumference measurements for which the difference between measurements of the professional and the non-professional as well as between the two occasions differed significantly ($p<0.001$). Findings of this study suggest that participatory nutritional status assessment procedure by community members is a fairly reliable procedure comparable to procedure administered by professionals. It can therefore be concluded that procedure by community members is useful and fairly reliable, giving results similar to a procedure administered by a professional for some anthropometric indices. Mid-upper-arm circumference seems to be a less reliable measurement compared to weight and height, indicating that their use in the participatory endeavour should be with caution.

Keywords: validation, prevalence, anthropometric measurements, mid-upper-arm circumference

INTRODUCTION

Participation and empowerment of communities especially those underprivileged have increasingly been advocated as prerequisites for achieving sustained development (Verhagen, 1984; Galaty, 1981). The Maasai and Batemi are among underprivileged communities in Tanzania. Their environments are undergoing drastic changes and deterioration which are partly due to both outside socio-economic pressure and encroachment by National Parks. These have negative nutritional and economic implications. The Maasai and Batemi of Ngorongoro are among those groups whose traditional food systems embody intimate knowledge of the environment and whose socio-economic and nutritional wellbeing rests on the integrity of their culturally mediated relationships with the environments in which they live. In such communities, not much has been explored by researchers. Moreover, unlike in other communities, meaningful development in these nomadic communities depends solely on local initiatives rather than external agents. That is why these communities decided to participate fully in the efforts to address health and nutrition problems right from the assessment stage so as to own whatever recommendations were going to come out of the assessment. The ownership of recommendations has a positive implication when designing interventions. This participatory research project was formulated and implemented jointly between a community organization known as Korongoro Integrated People Oriented to Conservation (KIPOC) and researchers. A team of community members conducted a community-based nutrition status assessment using simple and non-invasive methods.

A participatory procedure of such kind ascertains future action by communities but could compromise the quality of information generated by the community, in spite of the training, which normally precedes data collection. This necessitated testing the reliability of data collected by the community members in order to gain more insight into the usefulness of the participatory procedure. Normally, errors occur in nutritional anthropometry, which may affect the precision and accuracy of the measurement or indices. The errors can be attributed to three major sources namely measurement error, alterations in the composition and physical properties of certain tissues and use of invalid assumptions in the derivation of body composition from anthropometric measurements (Himes, 1987). Measurement errors may be random or systematic and include error resulting from inadequate training, instrument error and measurement difficulties. This article describes validity of participatory procedure in the hands of non-professionals and reliability of anthropometric measurements in assessing community nutritional status.

METHODOLOGY

Study Design

A cross sectional survey aiming at determining and describing prevalence of malnutrition in women and pre-school children using multiple methods and tools was done. The study team was composed of the community organization members as one part and investigators (professionals) as the other. KIPOC provided the local team from among the community members to administer the survey. The team was composed of one man and three women who volunteered to do the work on behalf of their communities. They were exposed to the methods for two weeks before doing the survey. A professional repeated the assessment done by the local team on the same subjects for a sub-sample.

Subjects

A total of 360 households picked randomly were covered by the local community team from which one woman per household and one child per household were measured. Out of a sample of 360 households, 52 were pregnant women and therefore were excluded from the analysis. The working sample eventually turned to be 308 women. For children, 66 households were not included in the sample because they did not have pre-school children therefore 294 children eventually formed the sample. However, at the analysis stage, 46 children had birth date records missing and therefore excluded from the analysis, reducing the sample further to 248 children.

Later, sub-samples of 66 households were picked from the same area and for this sub-sample, both local measurer and researcher took measurements. Again, 13 households out of these had no pre-school children and one had questionable age record hence the working sub-sample comprised 52 children. Similarly, 3 women in the sub-sample were excluded in the analysis as they were pregnant.

Sample Size

The sample determination was done based on a wider aspect of the survey reported elsewhere (Mselle, 1998). However, for assessing prevalence of malnutrition, a sample of 244 households was required. This was determined using the formula indicated in Equation 1 and assuming the number of pre-school children to be 1.5 per household as computed from 1988 National Population Census.

Equation 1:

$$N = 4Z\alpha^2 pq/d^2$$

Where

- N = desired sample size
- $Z\alpha$ = standard normal deviate
- p = proportion of pre-school children estimated to be stunted (which was 38.7%)
- $q = 1 - p$ = proportion of children who were estimated to be well nourished
- d = degree of accuracy desired = total width of 0.1; 95% confidence level

Sampling Procedure

The survey was done in Loliondo and Sale, two of the three divisions of Ngorongoro district. Ten villages (boma clusters) were selected randomly (using a random number table) from a list of all villages of Loliondo and Sale divisions. A random selection of households to be included was carried out within the participating villages. A list of all households in a village was used and a random start approach was employed whereby a starting point was determined randomly and thereafter interviews were carried out on one household after another until the required number for each village (30 households) was obtained.

Picking of chits randomly was employed for selecting a child to be picked in the selected household from among a list of children of that household. If a household selected had no preschool child, then no replacement was done. From each household one child and mother were included.

MEASUREMENT

A standard technique and equipment were used. Weight was recorded to the nearest 0.1 kg (accuracy of 100g) using a Seca electronic scale, while height and recumbent length was recorded to the nearest 0.1 centimetre (accuracy of 1mm) using a Teaching Aid at Low Cost (TALC) board. A non-stretchable measuring tape (recording to the nearest 0.1 centimetre) was used to measure mid-upper-arm circumference. Regular checking of accuracy of the scale was done using a known standard weight. Date of birth for children was recorded from either clinic cards or estimated from mothers' explanation for those with no cards. Before conducting the actual survey, pre-testing was done in a nearby village to check whether the survey tools were working as expected or not.

The local team collected data in the main survey before the same procedure was repeated jointly with the researcher about six months later in the sub-sample. In both cases (main sample and sub-sample) measurements were taken by the same member of the local team and the other members of the team handled the other aspects of the study (dietary intake interviewees reported elsewhere). For the sub-sample, subjects were measured twice by the local member and once by the researcher within the same week.

Data Analysis

The nutritional status of children was analyzed and evaluated in comparison with the commonly used U.S. National Centre for Health Statistics (NCHS) reference population as recommended by then by World Health Organization (WHO, 1983). Data were analysed using EPIINFO Version 6 – a computer programme (Dean *et al.*, 1994). Chi-square test and t-test were employed for testing statistical significance of proportions of malnourished subjects given by the two assessors.

RESULTS

General Characteristics of the Study Population and Comparison of the Two Data Sets

Based on the large sample (308 households) the mean age of the study children was 36±14.9 months while that of their mothers was 29.1±5.4 years (Table 1). The mean height of women was 160.2±5.7 centimetres. Women had a mean mid-upper-arm circumference of 24.7±2.6 centimetres while children had 14.4±1.4 centimetres. Body mass index (BMI) for women population was 20.0±2.5 while for children, mean z-scores ranged from –1.6 to – 0.6. When the validation sample was compared to the large sample to identify potential biases (Table 1), it was found that the two samples did not differ significantly except with regard to children's age ($p<0.01$) and children's height ($p<0.05$). The difference in mean age for the two data sets was still there even when a comparison was made for the same group of children above 23 months although reduced from 11.2 months to 7.8 months difference ($p<0.05$).

Table 1: Characteristics of the Study Population and Comparison of the Two Samples (Local Team Sample and Professional Sub-sample)

Group		Mean (SD)	Mean (SD)		Difference[1]	t-test
Women		n=63(local)	n=63(prof)	n=308(local)	0.09	
	Age (years)	29.0(8.0)	29.0(8.1)	29.1(5.4)	0.16	ns
	Weight (kg)	51.8(6.0)	51.8(5.9)	51.9(7.4)	1.06	ns
	Height (cm)	161.2(5.9)	161.2(5.9)	160.2(5.7)	0.10	ns
	BMI	19.9(2.2)	19.9(2.1)	20.0(2.5)	0.50	ns
	MUAC	24.7(2.0)	25.2(2.0)	24.7(2.6)	4.9	ns
	% lactating	82.0	82.0	77.1		
Children		n=52(local)	n=52(prof)	n=248(local)		ns
	Age (months)	47.9(12.9)	47.9(12.9)	36.7(14.9)	-11.2	P<0.001
	Weight (kg)	13.4(2.3)	13.3(2.3)	12.7(3.0)	-0.6	ns
	Height (cm)	97.6(8.3)	97.0(8.4)	91.9(12.6)	-5.1	p<0.05
	MUAC	13.9(0.9)	13.9(1.0)	14.4(1.4)	0.5	ns
	WHZ	-1.2(0.9)	-1.2(0.8)	-0.7(1.3)	-0.5	ns
	HAZ	-0.9(1.3)	-1.0(1.1)	-0.6(1.9)	-0.4	ns
	WAZ	-1.5(1.0)	-1.6(1.0)	-1.0(1.4)	-0.6	ns

1 – Mean for the large sample of local team minus mean for sub-sample of professional.

Prevalence of Under-nutrition in Preschool Children

Results from both data sets showed high prevalence of impaired growth. It is apparent from Table 2 that 22.2%, 23.8% and 16.1% of children in the age group assessed by the team were stunted, under-weight and wasted respectively.

Table 2: Prevalence of Low Anthropometric Indices for Children (12-71 months) as Assessed by the Community Members (n = 248)

Indicator	Proportion of the population (%)		
	Girls (n=144)	Boys (n=104)	Total
Height-for-age			
Below –2SD	14.6	26.9	22.2
Below –2SD	9.0	10.6	9.7
Weight-for-height			
Below –2SD	19.4	29.8	23.8
Below –3SD	4.2	11.5	7.3
Weight-for-age			
Below –2SD	13.1	20.2	16.1
Below –3SD	2.1	2.9	2.4
Wasting (MUAC)			
Below 13.5cm	19.6	22.3	21.7
Below 12.5cm	7.5	8.1	7.7

The proportions of severely affected were 9.7, 7.3 and 2.4% for stunting (Table 2), underweight and wasting respectively. Boys seemed to be more prone to become stunted ($p<0.01$) and under-weight ($p<0.05$) than girls. Except for low height-for-age (stunting), prevalence increased with age groups and peaked at 24-47 months age group. Low height-for-age was most prevalent at the age less than two years (Table 3),

Table 3: Proportion (%) of Children with Low Anthropometric Indices by Age Groups Based on Large Sample (n=248) and Based on the Sub-sample (n=52)

Age group	low WAZ		Low WHZ		Low HAZ	
(months)	<-2SD	<-3SD	<-2SD	<-3SD	<-2SD	<- 3SD
<24 (n = 31)	22.6	9.9	3.1	0.0	38.7	16.1
24 – 47 (n=130)	25.4	7.7	18.5	3.1	20.0	8.5
(n=21)[a]	19.0	0.0	4.8	0.0	14.3	0.0
48 – 59(n=46)	23.9	8.7	17.4	4.3	21.7	8.7
(n=11)[a]	54.5	9.1	27.3	9.1	18.2	0.0
60 – 71 (n=41)	19.5	2.4	17.1	0.0	17.1	9.8
(n=20)[a]	35.0	0.0	3.0	0.0	35.0	0.0

[a] = subsample

Under-nutritional risk in women

According to the assessment by the local team, 27.9% of the women's population was undernourished based on BMI indicator. When MUAC indicator was used different results were recorded. Low prevalence (10.9%) was recorded (Table 4) compared to the other indicators.

Table 4: Nutritional Status of Women Based on Anthropometric Indicators as Assessed by the Community Members

Indicator	Sample	Undernourished proportion (%)
BMI		
Below 18.5	287	27.9
Above 25.0	287	4.0
MUAC		
Below 22.0cm	358	10.9

BMI below 18.5 cut-off point assumed under-nutrition while above 25.0 assumed over nutrition
MUAC below 22-0cm cut-off point assumed under-nutrition

Comparison of Prevalence in the Two Data Sets

Table 5 compares results of children anthropometric assessment, done by the local team and that by the professional. According to the local team, prevalence of children under-nutrition were 16.1%, 22,2% and 23.8% for wasting, stunting and underweight respectively, while the professional data set gave similar prevalence of 19.2%. 23.1% and 30% for wasting, stunting and underweight respectively. However, as far as the prevalence of severe under-nutrition of children was concerned, the local team data set showed higher prevalence of severe stunting (9.7%) and severe underweight (7.3%) while the professional data set had no severe case and severe underweight was 1.9%.

Table 5: Impaired Growth/Malnutrition Prevalence as Assessed by Community Members and the Professional (n=249)

	Local team sample		Validation Local*		Sub-sample Professional**		Difference[a]	x^2 test[b]
Indicator	%	n	%	n	%	n	%	
Weight-for-height								
<-2SD	16.1	248	17.3	52	19.2	52	-3.1	ns
<-3SD	2.4	248	1.9	52	1.9	52	0.5	na
Weight-for-age								
<-2SD	22.2	248	24.5	52	23.1	52	-0.9	ns
<-3SD	9.7	248	0.0	52	0.0	52	9.7	na
Weight-for-age								
<-2SD	23.8	248	30.8	52	30.8	52	-7.0	ns
<-3SD	7.3	248	1.9	52	1.9	52	5.4	na
Mid-upper-arm.								
<13.5mm	21.7	249	24.5	52	28.8	52	-7.1	ns
<12.5mm	7.0	249	7.7	52	7.7	52	-0.7	ns

* – measure by local team ** measure by professional

a – local team - validation sub sample

b – computed by $\sum\frac{(\text{observed} - \text{expected} - 0.5)^2}{\text{expected}}$ for local team, large sample vs validation sample

Similarly, when the age range difference was controlled by excluding the children below 24 months of age in the community member data set, no substantial change was seen (Table 6). The comparison was based on Chi-square test after computation of differences in prevalence rates obtained through the two procedures (community member and that by professional). The Chi-square test was employed to know whether the differences were significant or not.

Table 6: Impaired Growth/Malnutrition Prevalence as Assessed by the Community Members and the Professional with Comparison of Children above 23 Months of Age (n=218)

	Local team Sample		Validation sub-sample by professional		Difference[a]	x^2 test[b]
Indicator	%	n	%	n	%	
Weight-for-height						
< -2SD	20.6	217	19.2	52	1.6	ns
< -3SD	3.1	217	1.9	52	1.2	na
Height-for-age						
< -2SD	21.3	217	23.1	52	-1.8	ns
< -3SD	8.1	217	0.0	52	8.1	na
Weight-for-age						
< -2SD	26.9	217	30.8	52	-3.9	ns
< -3SD	8.8	217	1.9	52	6.9	na
Mid-upper-circumference	26.7	218	28.8	52	2.1	ns
< 13.5mm	P>0.05 4.6	218	7.7	52	3.1	na
< 12.5mm						

ns = not significant na = not applicable a = local team minus validation sub sample

b – computed by $\sum\frac{(\text{observed} - \text{expected} - 0.5)^2}{\text{expected}}$ for local team, large sample vs validation sample

The same was observed when we compared the results of under-nutrition in women; the two data sets did not differ (Table 7). Prevalence of low BMI was similar, 25.4% and 27.9% for professional assessment and local team assessment respectively.

Table 7: Maternal Malnutrition Risks as Assessed by the Community Members and the Professional

	Local team sample		Validation sub sample (Local assessor)		(Professional)		Difference[a]	X^2 test[b]
	%	n	%	n	%	n		
Low BMI	27.9	287	25.4	63	25.4	63	2.5	ns
Low MUAC	10.8	358	1.5	63	1.5	63	2.5	na

ns = not significant, (P>0.05) = not applicable

a = local team minus validation sub sample

b = computed by $\Sigma\frac{(\text{observed} - \text{expected} - 0.5)^2}{\text{expected}}$ for local team, expected large sample vs validation sample.

Reliability of Anthropometric Measurements

When anthropometric data were subjected to two by two tables to compare the number of subjects categorized below various cut-off points by two assessors (community member and professional), results showed that use of low mid-upper circumference criterion and low body mass index in women gave relative prevalence of 4.0 and 1.0, respectively.

Comparison of measurements by the two measurers (local team member and professional) as well as measurements taken by the same measurer (local member) twice in one-week intervals showed no significant difference except for the measurement of the women mid-upper-arm circumferences (Table 8). Similarly, there was no difference in the two measurements taken within one-week for the same subject except for mid-upper-arm circumference.

Table 8: Comparison of Anthropometric Measurements Done by Professional and that by Community Member*

	Professional versus community member		Community member two occasions	
Measure	mean difference (SEM)	t-test	Mean difference (SEM)	t-test
Women (n = 63)				
Weight (kg	0.076 (0.207)	ns	0.39(0.28)	ns
Height (cm	0.065 (0.071)	ns	0.03 (0.19)	ns
MUAC (cm)	0.503 (0.114)	P<0.01	0.52 (0.17)	P<0.005
Children (n=52)				
Weight (kg)	0.12 (0.056)	ns	0.18 (0.13)	ns
Height (cm)	0.016 (0.83)	ns	0.10 (0.09	ns
MUAC (cm)	0.060 (0.060)	ns	0.39 (0.06)	P<0.001

ns – not significant

* Measurement by Community member was done by same measurer (Community Member) at two different occasions within a week using Mean Difference Test (paired t-test).

When the percentage difference between the measurements of children by the community member and measurement by the professional was computed, mid-upper-arm circumference had much higher percentage difference (9%) than any of the weight or height measurement (0.3 to 0.03%) as shown in Table 9. In short, it seems when measuring women, the local team member was recording about 50 smaller values than the professional and at the same time the precision was poor as a mean difference of 0.52cm was recorded.

Table 9: Variability of Measurements between Professional and Community Member*.

Variable	Measurements	t-test	Measurement	t-test
Women (n=63)	**Prof-Local[1] (mean± SEM)**		**First local – 2nd (mean± SEM)**	**local[2]**
Absolute[3] difference				
Weight (kg)				
Height (cm)	-0.08±0.21	ns	-0.30±0.28	ns
MUAC (cm)	0.07±0.07	ns	-0.03±0.19	ns
	0.50±0.11	p<0.01	0.52±0.17	
				p>0.005
Percentage[4] difference				
Weight	0.04±0.05	ns	-0.18±0.13	ns
Height	0.01±0.01	ns	-0.01±0.03	ns
MUAC	0.51±0.12	P<0.01	-0.52±0.17	P<0.01
Children (n=52)				
Absolute difference				
Weight (kg)	0.01±0.06	ns	-0.18±0.13	ns
Height (cm)	0.02±0.08	ns	-0.01±0.09	ns
MUAC (cm)	0.06±0.06	ns	-0.39±0.06	P<0.001
Percentage difference				
Weight	0.03±0.11	ns	-0.28±0.13	ns
Height	0.003±0.02	ns	-0.02±0.02	ns
MUAC	0.09±0.08	ns	-0.69±0.11	P<0.01

1 = from computation of absolute difference $\frac{[\Sigma(\text{prof-local})]}{N}$

2 = from computation of absolute difference $\frac{[\Sigma\ (\text{first measure-second measure})]}{N}$

3 = using absolute formula

4 = using percentage formula.

* Measurements by the Community Member done in two different occasions (precision)

DISCUSSION

As an attempt to explore the usefulness of the nutritional assessment on the community hands, this study has provided some remarkable experience as to what works and what does not. Among several assessment tools employed (others reported elsewhere), anthropometrics assessment showed high reliability. This attempt has become the first of its kind for the Maasai and Batemi cultures, as there isn't any other literature source indicating that participatory assessment of malnutrition has been done in these particular cultures, let alone a validation study. Findings of the present study were consistent with most of the national data. For instance in the Tanzania Demographic and Health Survey (TDHS) conducted in almost the same period (1996), national prevalence of under-nutrition among under-fives were reported to be 43.0, 30.0 and 7.0% for stunting, underweight and wasting, respectively (TBS, 1997). Mean BMI among Tanzanian non-pregnant women was reported to be 22.9 and 9.0% of them had BMI below 18.5 cut-off point.

Anthropometric indices are used as the main criteria for assessing the adequacy of diet and growth in children. In this study, the three most commonly used indices have shown the same trend, which has been reported in the previous studies. That is "each has a specific meaning in terms of the process (different combination of biological processes) or outcome of growth impairment" (WHO, 1995). Deficit in one or more of the anthropometrics indices is often regarded as evidence of malnutrition. In Maasai and Batemi communities, it appears wasting, stunting and underweight were problems for children in all age groups. This deficit in growth (faltering), indicating past or current malnutrition at the cellular level could be due to inadequacy of food or infectious diseases in these communities. This could be interpreted more appropriately as a result of interaction between poor diet and diseases. Normally, the proximal factors leading to malnutrition are inadequate dietary intake and disease and the distal factors are socioeconomic in nature and do not influence anthropometrics status directly but do so through proximal determinants via a number of pathways. For instance, poverty in these communities may have lead to poor food availability, inadequate health care, poor sanitation, all of which pose as great risk for disease and poor energy and nutrient intake. Elucidation of actual causes and pathways through which this brought about the observed high prevalence is important.

Observed critical prevalence of low weight-for-height (16% in the large sample and 19% in the sub- sample) in this study were not expected because normally in non-disaster areas, the prevalence of low weight-for-height is relatively consistent across developing countries and is less than 5% (WHO, 1995). Therefore, whether the situation was disastrous during the time of this study or the anthropometrics results overestimated prevalence, could not be established in this study. However, consistency observed with dietary intakes and haemoglobin level reported elsewhere (Mselle, 1998) suggests that children under-nutrition in the studied communities was high. Normally, high prevalence of low weight-for-height is indicative of severe recent or current events such as starvation or infectious diseases outbreak (WHO, 1995). Furthermore, wasting in children and low BMI in women are important criteria for identifying population to be targeted in intervention programmes. According to the guidelines of the WHO expert committee, a prevalence of above 39% of population with BMI less than 18.5 should be viewed as very high and between 20 to 30% should be viewed as moderate prevalence of malnutrition which was the case in this survey (Table 4).

Regarding a reliability test, the two assessors gave similar results except when assessment was based on height measurement or probing for age of kids from their mothers and MUAC in both children and women. Age range of children introduced slight difference in prevalence of under-nutrition (Table 1) on top of difference due to variation in measuring height between the two measurers. Prevalence of under-nutrition in women based on MUAC seemed to have suffered the same variation between the two measurers.

The community member seemed to be over-estimating prevalence of women under-nutrition when it came to use of MUAC indicator. When measuring children, relative prevalence of 1.17, and 1.1. were recorded using mid-upper-arm circumference and low weight-for-height, respectively. This is almost perfect agreement of the two assessors.

In that case, assuming that the measurement taken by the professional was the right (accurate) one, imprecision contributed more to the observed variation than accuracy especially for the case of measuring children.

CONCLUSION AND RECOMMENDATIONS

Results from this study suggest that malnutrition was high in Maasai and Batemi communities. Reliability of anthropometric measurements seems to be good even in the hands of non-professionals. However, MUAC seems to be a less reliable measurement compared to weight and height. Reproducibility of MUAC seems to be low especially when measuring women, so their use in a participatory endeavour should be with caution. Therefore, it can be concluded that communities would assess their nutritional status with minimum guidance of researchers in a participatory setting. Information gathered this way is still reliable if anthropometric assessment is employed as anthropometrics measurements have shown good reliability even in a participatory endeavour.

Management context of participatory research suggest that care is needed in selecting anthropometric indices to be used. This is because mid-upper-arm circumference measure seems to be less reliable compared to weight and height. It is therefore being recommended that use of mid-upper-arm circumference in participatory research and interpretation of resulting data should be undertaken with caution. On the other hand, weight and height indices are highly recommended for use in a participatory endeavour.

ACKNOWLEDGEMENT

We wish to express our appreciation to International Development Research Centre (IDRC) support that enabled implementation of this research.

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Verhegen*Cooperative for Survival. Analysis of An Experiment in Participatory Research and Planning with Small Farmers in Sri Lanka and Thailand*

ASSESSMENT OF COMMUNITY PARTICIPATION IN THE CSPD PROGRAMME IN MOROGORO, TANZANIA

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ABSTRACT

The aim of this study was to investigate the extent of community participation in the Child Survival, Protection and Development (CSPD) programme in two districts of Morogoro rural and Morogoro urban. Community members and project officers provided information to assess the situation whereby individual interviews and focus group discussions were conducted. The results of the study have shown that the extent of community participation in the CSPD project is generally low. More than half (52.2%) of respondents were not aware of the programme and its activities in their localities, which was also shown by 7 out of 12 focus group discussions that were held. The results have also shown that 70% and 73% of the respondents were not involved in the planning and implementation stages of the programme, respectively. The situation was worse for the monitoring and evaluation stage whereby none of the respondents reported to be involved. The observed poor community participation is an indication that somehow the CSPD programme has lost its effectiveness as a change agent. This is a signal towards a need to re-examine how the programme is currently being implemented. Being strongly embedded in the existing governmental administrative system, it might be that the programme has lost its initial goal. There may be a need to go back to the drawing board and re-design the whole set up of this important programme, which has really laid a good foundation in the way Tanzanians look and consider nutrition in the society.

Key words: CSDP, community participation, malnutrition, child survival, Morogoro

INTRODUCTION

Malnutrition contributes to over 6 million child deaths each year in developing countries, which is 55% of the nearly 12 million deaths among children under five years of age. About half of children under five years of age in South Asia and one third of those in sub-Saharan Africa are malnourished (UNICEF, 1998). To reverse the situation, Cerqueira (1992) and UNICEF (2002) suggested that people should be given the opportunity to participate actively in seeking solutions for their nutritional problems in order to have effective long-term impact in any intervention programme. In other words, programmes on nutrition improvement should emphasize the importance of active community participation in making decisions and finding solutions to their nutritional problems. Peoples' participation approach has also been shown to be necessary in reducing malnutrition in the communities (UNICEF, 2002).

The Child Survival, Protection and Development (henceforth CSPD) is a community-based programme whose main strategy is to empower communities to assess, analyse and take appropriate actions on developmental issues, especially those pertinent to health and nutrition situation of children and women. Although this programme was founded on strong community participation, at least at the time of its inception about two decades ago, its recent performance in those aspects has not been assessed comprehensively.

The CSPD programme is mainly a replication of the WHO/UNICEF/JNSP that started in 1983/84 in Iringa region and its aim is to improve the welfare of children and their mothers. It intends to combat malnutrition and provide nutrition education to children and women. Over time, the programme has successfully expanded to cover other regions (Morogoro, Shinyanga, Kagera, Ruvuma and Kilimanjaro). It has greatly empowered communities to handle food and nutrition health problems (Jonsson, 1988; Kavishe & Mushi, 1993). This is partly reflected by a significant reduction in child under-nutrition, especially severe underweight in areas implementing the CSPD programme (Kavishe and Mushi, 1993; TFNC, 1994).

This study was undertaken to assess the current extent of community participation in the CSPD programme in one of the regions that has been implementing the programme for about two decades.

METHODOLOGY

Location of the Study Area

The research was conducted in Rural and Urban districts in Morogoro region. Morogoro is among the first regions in Tanzania Mainland that started to implement the CSPD programme. Three wards were selected purposively from each of the two mentioned districts. While Kiroka, Mikese and Mkambarani were selected in Morogoro Rural district, three wards from the Urban district were Boma, Kilakala and Kingolwira. All six wards started to implement the CSPD programme in 1988. One village was randomly selected from each ward for the survey. The selected villages were Mkambarani (Mkambarani ward), Fulwe (Mikese ward), Kiroka (Kiroka ward), Mahakamani (Kingolwira ward), Ng'atigwa (Kilakala ward) and Madizini (Boma ward).

Research Design and Sampling Procedures

This study adopted a cross-sectional survey design. The study population consisted of community members in the selected villages and key informants from the CSPD management team. A total of 120 community members were selected using purposive sampling method consisting of 20 respondents from each village (10 men and 10 women). All the selected men and women respondents had at least two children of between zero to five years of age. Two focus group discussions (FGDs) were organized in each village, one for men and one for women. Three project officers were interviewed as key informants.

Criteria for Assessing Extent of Community Participation

Community participation was judged by assessing the extent to which local residents were taking part in various stages of the project, namely project onset/planning, implementation, monitoring and evaluation. Respondents were asked to indicate whether they were consulted to give their views concerning appropriate project activities during the project onset/planning. Participation in the project implementation was assessed by considering the number of respondents who took part in various project activities. In monitoring and evaluation, participation was assessed by the number of respondents who were involved in judging the projects' success at various stages.

Research Tools for Data Collection and Analysis

A semi-structured questionnaire was used to obtain information from the sampled community members in the six villages. The questionnaire consisted of both open and closed-end questions. Information about age, educational level and marital statuses were obtained using the closed-ended questions. The open-ended questions were used for soliciting information on the respondents' awareness about the programme and views pertaining to its implementation. Checklist questions were prepared to guide focus group discussions and interviews with key informants. Computer-based statistical software SPSS for windows version 11.5 was used for data analysis.

RESULTS AND DISCUSSION

Characteristics of the Sampled Community Members

The characteristics of the sampled respondents (members of community) in terms of marital status, age and education level are shown in Table 1. Most of the respondents were married (79%) while fewer were widowed, single or divorced. The majority of the respondents were aged between 20 and 40 years (86%) and only few respondents were more than 40 years. About half of the respondents had attained primary school education while a quarter of all the respondents had no formal education. Only 9% had attained secondary school education or beyond.

Awareness of Local Community on the Existence of the CSPD Programme

The results indicate that more than half of the interviewed respondents (52.5%) were not aware of the CSPD programme operating in their respective areas (Table 2). It is interesting to note that respondents from Morogoro Rural district were more aware (63.3%) about the programme than their counterparts in the Urban district (31.7%). The chi-square test shows that the difference was significant at $P < 0.001$. However, these results seem to contradict past studies that were conducted in the area with similar objectives. TFNC (1994) and Leveri (1995) reported no significant difference in awareness between respondents in Morogoro Rural and Urban districts with regard to the CSPD programme. On the other hand, assessment of the awareness of the programme among community leaders in the two districts by Msuya (1998) showed that the urban leaders were slightly more aware about the CSPD programme compared to their rural counterparts.

It may be difficult to tell the exact cause of the difference in awareness between the rural and the urban respondents observed in this study. However, possible explanation might be that given the current changes in policies in the country especially with regard to trade liberalization and political multi-partism, urban dwellers are increasingly becoming targets for many activities such as commercial promotions and political campaigns or rallies so much so that they might be paying less attention to community activities such as those of the CSPD programme.

Other results in Table 2 indicate that the main objectives of the CSPD programme were not very clear to most of the community members. The majority of the respondents (84.2%) opined that the main objective of the programme was to following up on the health of the mother and child. Others said the objectives of the programme included provision of vaccination to children (36.8%), making follow-up on child health (14.2%) and educating women on health issues (33.3%). These disparities are not surprising given the low levels of awareness noted above.

Levels of Community Participation in the CSPD Programme at Various Stages

a) Onset and Planning Stage

Table 3 also indicates that members of the communities were not actively involved in the project during onset and planning stages. In total, the majority of respondents (69.2%) were not involved in the identification of community health problems, which included 80% and 58.3% of the Urban and Rural districts, respectively. The chi-square test showed a significant difference ($P<0.01$) between the two districts. Eleven out of the 12 groups involved in the focus group discussions reported that they had not been involved in the identification of community health problems; six of these groups were from Morogoro urban and five from Morogoro rural.

The table also reveals that it was not very clear, to most of the respondents (42.5%), who was responsible for the conceptualization of the CSPD programme. Thirty three percent of respondents mentioned a special committee to have been responsible whereas 28.3% reported that it was the people who were working in the CSPD programme, and 17.5% reported health officers to have been responsible. On the other hand, 8.3% thought that it was the women who were responsible for the conceptualization.

According to URT and UNICEF (1992), a unique feature of the CSPD project in Tanzania is its emphasis on decentralization of decision-making, with effective use of a bottom-up approach. The importance of this feature has also been pointed out in literature. For example, FAO (1993) emphasizes that the community should be fully involved in the identification of project activities, setting project goals and objectives, discussing feasibility and cost effectiveness of the activities and establishing time frame for each activity. The advantages of community participation particularly in decision-making have been widely reported. For example, Jonsson (1988) reported such advantages while assessing the community based nutrition programme in Southern Asia. The consequences of failure to allow the community participation have also been reported in the literature (Gillespie *et al.* 1996).

b) Project implementation

Results showed that the majority of the respondents (73.3%) were not involved in the project implementation (Table 4), which included 81.7% in Morogoro urban and 65% in Morogoro rural. However, the difference was not significant using chi-square statistics. This observation was also echoed in the focused group discussions whereby 9 groups, 5 from urban and 4 from rural, out of the 12 indicated that they were not involved in the implementation of the CSPD activities.

Respondents gave several reasons for not taking part in the programme implementation. While the majority (41.7%) could not give any reason, about one third (31.7%) reported that the authority did not involve them. Chi-square statistic indicated that the differences in the two districts were significant at $p < 0.05$.

c) Monitoring and Evaluation of the Programme

Results of the interviews revealed that none of the respondents in both Morogoro urban and rural districts was involved in evaluating whether the activities of the programme were being met or not. The same type of findings were noted in focus group discussions whereby only one group in Morogoro Rural district (out of the six) reported to have observed members of community being consulted to help planners in evaluating whether programme objectives were met. However, the reported community consultation did not involve deciding the criteria for assessing achievement of the project objectives or how to monitor project activities.

FAO (1993) urges participatory monitoring and evaluation to be an essential aspect of a community-based nutrition project or programme whereby it enables the community to assess the progress of the activities and take steps to resolve problems including changing the objectives and adjusting activities if necessary. However, it appears that in case of the CSPD this was not practised although the underlying philosophy of CSPD requires exactly that.

CONCLUSION AND RECOMMENDATIONS

It is apparent from the results of this study that community participation in the CSPD programme is unexpectedly low. While this seems to be true for all stages of the programme that were assessed (planning, implementation and monitoring and evaluation), the situation appears to be worse in the latter. Being a community-based programme, CSPD is governed by strong participatory approach starting from the village level. For example, the programme is supposed to involve the community through village health committees, which meet quarterly to discuss and review the nutritional and health status and forward their recommendations to the higher administrative level, for this case the ward. The CSPD programme advocates a bottom-up approach in all its decision-making cycles (in planning, implementation and monitoring and evaluation). In such a situation, one would expect the community members to be well-informed about the programme and its activities. However, more than half of the interviewed respondents in this study were not aware of the CSPD programme and its activities. This implies that there is poor communication between this supposedly important change agent and the beneficiaries.

Given that the main strategy of CSPD is to empower communities to assess, analyse and take appropriate actions on the nutrition of children and women, it is doubtful whether this strategy is really being employed. The observed poor community participation coupled with the reported poor nutrition situation in the region, is an indication that somehow the CSPD programme has lost its effectiveness as a change agent. There is therefore a need to re-examine how the programme is currently being implemented. Being strongly embedded in the existing governmental administrative system, it might be that the programme has lost its initial objectives that it was intended for. If that is the case, there is a need to go back to the drawing board and re-design the set up of this important programme, which has really laid a good foundation in the way Tanzanians look and consider nutrition in the society.

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Table 1: Percentage Distribution of the Sampled Respondents According to Selected Socio-demographic Characteristics

Variables	Location		
	Morogoro Urban (n=60) %	Morogoro Rural (n=60) %	Total (n=120) %
Marital status			
Married	76.7	81.7	79.2
Widowed	5.0	5.0	5.0
Single	18.3	11.7	15.0
Divorced	0	1.7	0.8
Age (years)			
20-30	23.3	15.0	19.2
31-40	63.0	70.0	66.7
41-50	8.3	11.7	10.0
51-60	5.3	3.3	4.2
Education level			
No formal education	25.6	26.7	25.8
Adult education	16.7	6.7	11.7
Primary education	55.0	51.7	53.3
Secondary education	1.7	6.7	4.2
Colleges	1.7	8.3	5.0

Table 2: Extent of Awareness of Respondents about the CSPD Programme

Variable	Location			
	Morogoro Urban (n = 60) %	Morogoro Rural (n = 60) %	Total (n = 120) %	Chi-square value
Awareness about CSPD programme				
Aware	31.7	63.3	47.5	12.06***
Not aware	58.3	36.7	52.5	
Perceived main objective of the programme[1]				
To educate women about health	14.3	36.8	33.3	
To follow-up on the health of child and mother	89.0	81.6	84.2	
Vaccination to children	26.5	42.1	36.8	
Follow-up on child health only	10.5	15.8	14.2	

Note: *** = Significant at P < 0.001

[1] Some of respondents gave more than one option, hence percentage would not necessarily add to 100%.

Table 3: Level of Community Participation in the Programme Onset and Planning Stage

Variables	Location			
	Morogoro Urban (n=60) %	Morogoro Rural (n=60) %	Total (n=120) %	Chi-square value
Reported involvement				
Involved in the identification	20.0	41.7	30.8	6.60**
Not involved in the identification	80.0	58.3	69.2	
Involved in the conceptualisation	0	0	0	
Reported party responsible for conceptualisation of the programme				
Health officers	18.3	16.7	17.5	
A special committee	5.0	1.7	3.3	15.42**
People in the office	23.3	33.3	28.3	
Don't know	53.3	31.7	42.5	
Women	0	16.7	8.3	

Note: ** = Significant at $P < 0.01$

Table 4: Level of Community Participation in the Programme Implementation Stage

Variables	Location			
	Morogoro Urban (n = 60) %	Morogoro Rural (n = 60) %	Total (n = 120) %	Chi-square value
Involvement in the programme implementation				
Involved	18.3	35	22.9	2.72 n.s.
Not involved	81.7	65	73.3	
Reasons for not making decision on how to run the activities of project				
Don't know if there is such a programme	33.3	20.0	26.7	6.16*
Were not involved by the authority	33.3	30.0	31.7	
No response / could not tell	33.4	50.0	41.6	

Note: n.s.= non-significant (at $p \leq 0.05$)

* = Significant at $p \leq 0.05$

QUANTIFICATION OF DIFFERENT CYANOGENIC COMPOUNDS IN CASSAVA PROCESSING STEPS INTO *UGALI* AND IN WATER USED FOR SOAKING CASSAVA ROOTS

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ABSTRACT

The study was undertaken to quantify total cyanogen, glucosides, cyanohydrin and free cyanide (HCN) residues after processing cassava roots by soaking in water and sun drying, in flour, *ugali* and in the water used for soaking. Samples of fresh cassava roots were obtained from a local market in Tanzania. The processing steps in both soaking and sundrying were observed to be effective in the reduction of cyanogens. Soaking method alone reduced total cyanogens by 83% (on dry weight basis), glucosides by 95% and cyanohydrin by 53% and free cyanide by 98%. After six days of soaking, the sun drying method reduced total cyanogens by 52%, glucosides by 78%, cyanohydrin by 40% and free cyanide by 31%. After six days of sun drying, *ugali* prepared using flour from pre-soaked sun dried cassava contained 6.2% of the raw cassava roots total cyanogens, whereas that prepared from flour obtained from sun dried cassava had 15% of total cyanogens. Of all the steps taken in cassava roots processing, the most effective according to these results seem to be those of comminuting or tissue softening and slow sun drying. Overall, soaking of cassava roots in water is more effective in reducing cyanogenic compounds as compared to sun drying. Water used for soaking cassava roots contained total cyanogens up to 172.2 mg/l. This level is by far above the WHO (1982) upper limit of 0.2 mg/l for disposal water quality guidelines. This calls for appropriate disposal of water used for soaking cassava roots as it might have adverse effects on the environment and ecosystems.

Keywords: cassava, cyanogens, cyanohydrin, glucosides, soaking, sun drying, *ugali*.

INTRODUCTION

Cassava *(Manihot esculenta* Crantz) was introduced to Africa in the late half of 16th century from South and Central America, where it is believed to have originated (Lancaster and Books, 1983). Cassava is a member of the *Euphorbiaceae* family and it is a perennial shrub crop. It is a crop that propagates mainly through stem cuttings under natural conditions and through breeding (Acland, 1971). Cassava (*Manihot esculenta* Cruntz) is widely grown in several countries of sub-Saharan Africa where it ensures food security for large numbers of people living under unpredictable socio-political and ecological circumstances (Ihedioha and Chineme, 1999). The main advantages of cassava include its tolerance to drought, resistance to pests and its ability to grow under sub-marginal agronomic soils and climatic conditions (IITA, 1990). The crop provides an important source of carbohydrates for over 500 million people living in tropical countries. In Africa, the per capita consumption averages 102 kg/year (Ihedioha, 2002), and consumption rate is estimated to grow at 2.5 – 3% per annum (Gomez *et al.*, 1984). It is also expected that the population dependent upon cassava will double by the end of this century (FAO, 1986).

In terms of energy production, cassava ranks fourth after rice, wheat and maize in developing countries (de Bruij and Frescop, 1989). Over two thirds of the total production of cassava is consumed in various forms like *fufu*, *gari*, *ugali*, beer and other alcoholic drinks in Africa (Gidamis *et al.*, 1993; Essers *et al.*, 1993). Cassava is also used as the main ingredient in formulating starch-based diets meant for specific groups (Toure *et al.*, 2003). It is also used as a source of ethanol for fuel, animal feed and industrial starch (Lancaster *et al.*, 1982). The roots are the main edible part of the cassava plant; and the leaves are also edible and have protein content that is comparable to that of *Moringa oleifera* leaves (Gidamis *et al.*, 2003). The use of cassava and its processed forms as food is, however, constrained by its content of toxic cyanogenic glucosides and its low and poor quality protein content (Ihedioha, 2002; Adindu *et al.*, 2003). The toxicity is due to cyanide liberated from cyanogenic compounds by endogenous enzymes (Cooke and Dela Cruz, 1982). Enzymic hydrolysis of cyanogenic glucosides occurs whenever plant tissues are damaged or disrupted. Digestive enzymes in the gut may cause further hydrolysis when cassava is consumed (Okolie and Ugochukwa, 1988). Exposure to cyanide resulting from partial processing of cassava roots can lead to acute and chronic toxic effects, while consumption of cassava products containing cyanogenic glucosides above the lethal minimum of 0.5-3.5 mg HCN/kg body weight may lead to mental confusion, paralysis, breathing problems, goitre, cretinism (Cooke, 1983) and *konzo* (Ernesto *et al.*, 2002).

In Tanzania the roots of cassava are commonly processed into flour which is then used to make *ugali*, while roots of sweet varieties are also eaten as a snack after roasting or as fried chips (Gidamis *et al.*, 1993). The most commonly used traditional processing methods in the tropics are direct sun drying of peeled roots for 1-2 weeks into a storable product known as *Makopa* (Msabaha *et al.*, 1986) and fermentation of peeled roots by soaking in water for several days followed by sun drying (Zvauya *et al.*, 2002). Other traditional methods include solid-state fermentation of peeled roots in covered heaps to enhance mould growth. The different dried products obtained can be stored and subsequently milled or pounded into flour used for making different food products.

The need to reduce or eliminate toxic cyanogens in cassava has resulted in the development of both traditional and modern detoxification methods. These methods include those that are physical in nature (Bainbridge *et al*, 1998; Sopade, 2000), chemical (Ihedioha, 2002), microbiological (Oboh and Akindahunsi, 2003), breeding (Iglesias *et al.*, 2002) and various combinations of these methods. Two traditional methods of processing cassava roots that are commonly practised in Tanzania are soaking in water and sun drying. In the present study, the effectiveness of these two traditional methods in reducing cyanogenic compounds was assessed. In addition, the information on the cyanide contents in cassava roots and the water used for soaking is scanty. The amount of cyanogenic compounds in water used for soaking needs to be assessed as the wastewater is usually disposed haphazardly. Consequently, the cyanide present can find its way into water supplies, which may cause disastrous effects when the levels exceed the permitted ones.

MATERIALS AND METHODS

Fresh cassava roots were obtained from Morogoro municipal market in Tanzania. The traditional methods of processing cassava roots by soaking and sun drying of peeled roots were simulated in the laboratory. Both root processing methods were set up on the same day using the same batch of cassava roots, containing 40-50 roots per process.

Effect of Sun Drying on Cyanide Content Process

The roots were peeled and sliced into small pieces of 30 to 40 mm thick, thoroughly mixed and sun dried for five days. Dried slices were pounded into flour and sieved to remove particles above 500 microns (mesh no. 30). *Ugali* was prepared from the flour by mixing small amounts of flour in cold water and bringing it to the boil with continuous stirring with a wooden spoon. More flour was added until stiff with the final flour to water ratio of 1:2. In each step of the process, samples were taken for duplicate determination of cyanogen levels, pH, and moisture content. The pH measurement and moisture content determination were carried out according to AOAC (1984) methods. Total glycosides, cyanohydrin and free cyanide contents were determined using the enzymatic calorimetric method of Cooke (1978) with the modification described by O'Brien *et al.*. (1991). Cyanogenic contents were then calculated as described by Cooke (1983).

$$\text{Cyanide as HCN (mg kg}^{-1}\text{)} = \frac{10V.A_{620}}{A_{620}eq.DW}$$

Where V = Total extract volume (ml)

$A_{620}eq$ = Adjusted absorbance at 620nm corresponding to 1μg HCN derived from the HCN calibration curve

DW = Dry weight of sample (g)

The amounts of glucosidic and non-glycosidic cyanogens were then obtained as follows:

Glycosidic cyanogens = Total cyanogens – Non-glycosidic cyanogens

Cyanohydrin = Non-glycosidic cyanogens – Free cyanide.

Effects of the Soaking Process on Cyanide Content

Cassava roots were peeled and 3.5kg portions were separated and put into four labelled buckets each with a capacity of about 20L. One bucket (fifth bucket) containing cassava was set aside as a stock from which daily sampling of the roots was done for cyanogens, pH and moisture content analyses. This was to give variation of cyanide levels in soaked roots. To each of the four buckets, about 12L of tap water was added. Three roots were taken daily from buckets labelled 1 to 4 for duplicate determinations of cyanogens, pH and moisture contents as described in the sun drying process. The roots were soaked for six days after which soaking samples were sliced and sun dried for three days. Flour and "*ugali*" were prepared as described previously above.

Statistical Analysis

The data were analyzed using MSTAT statistical package. Mean range was used to compare the treatment means at 5% level of significance (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Effect of Sun Drying on Cyanide Levels in Cassava Roots Processed into *ugali*

Sun drying of peeled cassava roots resulted in reducing total cyanogens by 52% (dry weight basis) by the fifth day of drying (Table 1). The process of making flour reduced the total cyanogens by a further 21%, amounting to the loss of over 73%. In the final product, "*ugali*," the total cyanogens loss increased to over 85%. Of the cyanogenic components, cyanohydrin was found to be the predominant residual, with 67% of the original amount remaining in *ugali*. In general during the sun drying process, gradual degradation of cyanogens was observed. As the drying process progressed, the percent reduction of total cyanogens increased. This observation suggests that extending sun drying may reduce the cyanogenic compounds further. Essers *et al.* (1993) had observed that extended sun drying up to 25 days could reduce cyanogens to safe levels but during food shortage this practice may not be followed to completion because of the urgent need of obtaining food to eat. The degradation of cyanogens during sun drying may be attributed to the action of endogenous enzyme, linamarase. Contact between the enzyme and its substrate, linamarin is facilitated by slicing the peeled roots prior to sun drying. The stability of the enzyme linamarase at moderate drying temperatures of less than 40°C has been observed by Yeoh, (1989). The hydrolysis of cyanohydrin to HCN and acetone has been attributed to the secondary enzyme, α-hydroxiynitrile lyase (Conn, 1973) and exposure to pH between 4 and 5, (Fomunyam *et al.*, 1985). Low levels of HCN were observed throughout the sun drying process hence explaining the implying low level of degradation of cyanohydrin as well as rapid removal of HCN by air. Sun drying in free air therefore facilitated volatilization of HCN as it has a boiling point of 26°C.

Table 1: Cyanogenic Residual Levels during Sun Drying of Peeled Cassava Roots and in *Ugali*

Process	Day	Moisture content (%)	pH	Cyanogens ($mgkg^{-1}$, d. w.b)*				Percent loss TCG
				TCG	Gln	Cyh	HCN	
	0	55.48	7.5	302.4±26.3	261.6±22.3	38.90 ±3.4	1.90±0.6	-
	1	41.41	6.9	280.01±23.3	1.33± 0.6	269.10±22.5	9.67±0.4	7.28
	2	24.41	6.6	275.07±21.4	ND	248.44±21.2	27.45±1.5	8.94
Drying	3	10.24	6.5	200.26±13.5	13.38 ±0.3	169.08 ±2.4	17.54 ±0.8	33.77
	4	7.08	5.8	160.00± 9.8	20.93 ± 1.5	130.01 ±8.1	9.06± 0.2	47.08
	5	1.08	5.8	146.00± 8.3	7.04 ± 0.1	129.08 ±8.0	9.88 ±0.2	51.71
Flour	6	1.01	6.1	82.34 ±19.2	57.57±13.7	23.45 ±4.6	1.32 ±0.9	72.77
Ugali	6	27.6	6.5	43.26±6.5	15.05±0.76	26.22 ±5.41	1.99 ±0.33	85.69

* Each result is the mean of two independent determinations (± = mean range)

ND = Not detectable

TCG = Total cyanogens, Gln =Glucosides, Cyh = Cyanohydrin, d.w.b.= dry weight basis.

$$\text{Percent loss TCG} = \frac{TCG_o - TCG_a}{TCG_o} \times 100$$

TCG_o and TCG_a are total cyanogen contents before and after processing stages respectively.

Effect of Soaking and Sun Drying on Cyanide Levels in Cassava Roots Processed into *Ugali*

The soaking of peeled cassava roots for six days resulted in 82.2% reduction of total cyanogen content (Table 2). The subsequent process of sun drying preceded by slicing, further reduced total cyanogen contents up to 88.5%. The comminution process removed a further 3% of the total cyanogens while the making of *ugali* removed 2%, resulting in 94% reduction for the whole process. During soaking, the initial total cyanogen reduction was gradual but a rather rapid removal of cyanogens was observed in the fourth day of soaking when the pH decreased to 5.6. This reduction may be explained by the tissue degradation and softening during soaking which leads to solubilization of cyanogens into the soaking water. Microbial growth may have contributed to cyanogen loss by means of enzymatically induced cellular disruption, or by production of β-glucosidases, or by both. Microbial linamarase–type activity has been observed by several authors (Okofor and Ejiofor, 1986; Essers and Nout, 1989) in soaked cassava roots. The observed steep change in pH during soaking signifies rapid fermentation. The pH change during soaking of cassava roots has been attributed to lactic acid bacteria (Okafor *et al.*, 1984) and softening due to pectinolytic and cellulolytic enzymes (Padmaj, *et al.*, 1982). The cellular disruption, which occurs during root softening, clearly facilitates contact between enzyme, linamarase, and its substrate, linamarin. The more rapid hydrolysis of total cyanogens was therefore consistent with the greater degree of root softening.

Table 2: Cyanogenic Residual Levels during Soaking and Sun Drying of Peeled Cassava Roots and in Subsequent Flour and *Ugali*

Process	Day	Moisture content (%)	pH	Cyanogens ($mgkg^{-1}$, d.w.b)*				Percent loss TCG
				TCG	Gln	Cyh	HCN	
	0	60.2	7.3	291.11 ±23.0	193.0±16.00	85.66 ±6.2	12.45±0.8	-
	1	61.50	6.8	130.02 ±11.10	4.88± 1.10	112.79±9.1	12.35± 0.9	55.18
Soaking	2	61.50	6.1	128.01±10.40	0.91± 0.10	121.70±9.8	5.40 ±0.5	55.87
	3	62.21	5.9	126.10± 11.0	ND	120.35±8.6	5.75± 0.80	56.53
	4	62.21	5.6	52.0± 3.10	32.56 ± 2.29	19.03± 0.8	0.41± 0.01	82.07
	6	62.21	5.4	50.11± 2.90	9.36± 0.59	40.62± 2.3	0.13±0.002	82.27
Sun dried	11	2.64	5.7	33.22 ± 2.0	3.79± 0.06	24.6 ± 1.4	4.83 ±0.54	88.54
Flour	12	2.40	5.8	23.22± 1.20	ND	16.95± 0.5	6.27± 0.4	91.99
Ugali	12	20.76	6.0	18.24 ± 1.3	9.36± 0.36	7.66± 0.90	1.22± 0.04	93.71

* Each result is the mean of two independent determinations (± = mean range)

ND = Not detectable

TCG = Total cyanogens, Gln = Glucosides, Cyh = cyanohydrin, d.w.b. = dry weight basis

$$\text{Percent loss TCG} = \frac{TCG_o - TCG_a}{TCG_o} \times 100$$

TCG_o and TCG_a are cyanogen contents before and after processing stages respectively.

Water Used for Soaking Cassava Roots

The mean total cyanogen content of water used for soaking cassava roots was about 131 mgl^{-1} (Table 3). The highest level of cyanogens in water was observed on the second day of soaking while the lowest level was observed in the sixth day. This observation is consistent with the one made earlier, on tissue softening during soaking. Linamarin is water soluble so it is easily dissolved in water. In the subsequent days of soaking the level of cyanogens decreased steadily. This decrease implies possible degradation of linamarin by dissolved linamarase into water. Microbial activity as explained previously may have contributed to degradation of the solubilised cyanogens. During soaking low levels of HCN were observed. In general, water used for soaking tends to accumulate considerable amounts of total cyanogen and cyanohydrin, as a result posing environmental danger if the water is discarded without appropriate treatment. The observed maximum total cyanogens level of over 172 mg/l is very high when compared to the 0.2 mg/l permitted in disposal water (WHO, 1982).

Table 3: Cyanogen Contents in Water Used for Soaking Peeled Cassava Roots

Day	pH	Cyanogen content, (mgl^{-1})*			
		TCG	Gln	Cyh	HCN
1	5.5	130.97 ± 6.91	3.79 ± 0.77	119.87 ±5.13	7.31 ± 1.01
2	5.3	172.20 ± 8.38	41.52 ± 2.25	124.99 ±5.61	5.69 ± 0.52
3	5.5	132.20 ± 6.13	23.72 ± 1.11	103.24 ± 4.52	5.24 ± 0.50
4	5.6	110.37 ± 4.78	7.71 ± 0.91	95.78 ± 3.36	6.88 ± 0.51
5	5.7	108.16 ± 5.22	39.70 ± 1.43	67.91 ± 3.24	0.55 ± 0.02

*Each result is the mean of two independent determinations (± = mean range)

TCG = Total cyanogens, Gln = Glucosides, Cyh = cyanohydrin

$$\text{Percent loss TCG} = \frac{TCG_o - TCG_a}{TCG_o} \times 100$$

TCG_o and TCG_a are cyanogen contents before and after processing stages respectively.

CONCLUSIONS

Both traditional methods (soaking and sun drying) of processing cassava roots resulted in substantial reduction of total cyanogen content. The sun drying of sliced peeled cassava roots appeared to be less efficient in cyanogens reduction when compared with soaking of peeled cassava roots. The importance of the final processing steps of flour and *ugali* preparation is evident in the total cyanogens reduction. Based on the results of residual levels of cyanogens in the final product, *ugali*, soaking of peeled cassava roots for six days appears to be an efficient traditional method of cyanogens reduction.

Water used for soaking peeled cassava roots contained substantial amounts of total cyanogens and cyanohydrins accumulated in soaking water. If large quantities of cassava roots are processed by soaking, the cyanogens in water can be a serious problem to the environment. It was also observed that there was a gradual decrease in all the three types of cyanogens after the second day of soaking. This implies that as water is allowed to stand, much of the cyanogens are being degraded to HCN, which easily escapes into the atmosphere. This can be a problem when inhaled or when it dissolves in rainwater and finds its way into water reserves. This might have a profound effect in different ecosystems.

RECOMMENDATIONS

Soaking cassava roots in water for up to six days was the most effective method of reducing cyanogens from the roots. It is therefore recommended as the best method for cyanide removal from cassava roots. Care must be taken during the disposal of the soak as this may have adverse effects on the ecosystem if it finds its way to the water reserves.

ACKNOWLEDGEMENT

The authors wish to acknowledge the financial assistance received from the Norwegian Agency for Development Cooperation (NORAD) through the Cassava Project in the Department of Food Science and Technology, Sokoine University of Agriculture (SUA) in undertaking this study.

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EFFECT OF GRADING ON DEHULLING QUALITY AND CHEMICAL COMPOSITION OF DIFFERENT SORGHUM VARIETIES

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ABSTRACT

Sorghum dehulling is a necessity in producing an acceptable product, be in form of whole grain or flour. If not properly done, it leads to nutrient losses, the extent of loss depending on endosperm texture. This study was therefore conducted to assess the effect of grading on these dehulling losses for selected local and improved sorghum varieties produced in Tanzania. Sixteen sorghum varieties were screened using sieves of 4.0, 3.5, 3.0, 2.5 and 2.0 mm aperture sizes. Different grades of grain sizes were obtained ranging from 2.0 - 3.5 mm. Shaking was standardized by using a mechanical shaker at the same speed of 60rpm for 7 minutes. The graded and ungraded samples were dehulled using Tangential Abrasive Dehulling Device (TADD), for different dehulling times (2, 4, 6 and 8 minutes). Screening operation showed that there were some local sorghum varieties, which resembled improved varieties, based on size distribution. Results on dehulling studies showed that dehulling losses increased as dehulling time increased. Generally, grading reduced dehulling losses in more than 50% of the samples investigated. It was also observed that grading was more advantageous to sorghum varieties, which had a broad range of grain sizes, since more than 80% of the samples that had a broad range of grain sizes, had dehulling losses reduced by grading. Given the wide variation in sorghum germplasm in the country, the study recommends more studies to be conducted to confirm these results, since only sixteen local varieties of sorghum were used in this study.

Keywords: sorghum, dehulling, size grading.

INTRODUCTION

Sorghum (*Sorghum bicolour* (L) Moech) is today a cereal which is expanding most in acreage due to its excellent adaptability to semi-arid climates. It is one of the cereal foods for the majority of the population living in the semi-arid areas of Tanzania. Nearly all varieties of sorghum and millets grown in the country are local types. They have low yield potential resulting in insufficient supplies of food to meet the demand of the populations living in the marginal rainfall areas (Saadan and Mndolwa, 1993).

Sorghum and millets are important crops in the national economy, as they are widely regarded as food security crops. According to the National Agricultural and Livestock Research Master Plan (NARLM) drawn in 1989, sorghum and millet had received low priority. However, due to frequent drought spells and unreliability of rainfall, sorghum and millet have remained the most reliable food crops in the semi-arid regions of Tanzania (Saadan and Mndolwa, 1993).

Post-harvest food losses that take place during harvesting, transportation, preparation, processing, preservation, storage and consumption (FAO, 1985), has become the public significant problem for many years worldwide particularly in developing countries, Tanzania inclusive. Losses experienced during dehulling (decortication) are both quantitative and qualitative. Dehulling by mortar and pestle or with abrasive dehullers removes the grains' outer layers. As such, dehulled kernels have reduced levels of fibre, ash and fat (Chibber *et al.*, 1978; Eggum *et al.*, 1983; Serna-Saldivar *et al.*, 1987, 1994). Dehulling also results in diminution of protein content (Perten, 1977; Reichert & Young, 1977). Eggum *et al.* (1982) reported that the removal of 20 to 25% of the sorghum weight by traditional manual decortication decreased lysine levels by 40%. Serna-Saldivar *et al.* (1987, 1988) reported losses of 14% lysine in sorghum decorticated to remove 10% of its initial grain weight. Novellie (1982), has also reported that dehulling removes the husk, tannins and some valuable nutrients.

Generally, the nutritional value is adversely affected by dehulling (Desikacher, 1982). Depending on the extent of dehulling, the aleurone layer, which may contain protein, phytin, minerals, vitamins, enzymes, oil and pericarp, which is rich in lysine, threonine, serine, valine and glysine may be removed. Longer dehulling times in attempt to get acceptable white product can give rise to even bigger losses (Hotland, 1994). As far as the decortication losses are concerned, there is a great need to establish a way which can help to reduce dehulling losses. Therefore, a study was conducted to assess the effects of grading on dehulling losses in a way to reduce the losses and improve the nutritional value of the products.

MATERIALS AND METHODS

Two sorghum varieties, *Tegemeo* and *Pato* were obtained from Ilonga Agricultural Research and Training Institute, Morogoro. *Lugugu* and *Udo* (from Dodoma) *Madibwa* (from Singida), *Mawilu* (from Shinyanga) and *Nkansa, Mbangala 1&2, Songea, Mngindo, Kalionje, Madibwa, Kibaha local, Mboile* and *Msinga wa nyumbu* from Coast regions. All varieties were free from insect infestation and were not treated by pesticides.

Each sorghum variety used in the study was screened using sieves of 4.0, 3.5, 3.0, 2.5 and 2.0 mm aperture sizes to get grains of different size groups. Shaking was standardized by using a mechanical shaker (Retsch type) carrying the shaking at the same speed of 60 rpm for 7 minutes. Different size proportions obtained from this sieving were weighed using Oertling OB152 weighing balance and kept in polythene bags with appropriate labelling.

Ungraded glume-free and graded sorghum (20g each) were weighed in each grain size and kept in properly labelled and capped plastic containers. This operation was done eight times repeatedly for each ungraded and graded sorghum sample. These were then dehulled. The weight of grains before and after dehulling was recorded for every sample that was dehulled.

Each sample weighing exactly 20g was placed in the cups of Tangential Abrasive Dehulling Device (TADD) and dehulled for different dehulling times, 2, 4, 6, and 8 minutes, in duplicate. The dehulled samples were removed from the cups by using a vacuum sample collector and their weights after dehulling recorded. The percentage of dehulling losses was calculated using the formula:

$$\%\ \text{dehulling loss} = \frac{\text{Loss after dehulling X 100}}{\text{Initial weight of grain}}$$

Whole sorghum grain, ungraded dehulled and graded dehulled samples were separately ground by using a cyclone sample mill grinder. The flour obtained from each sample was analyzed for moisture content, total ash and protein. Moisture content was determined on 1g sample using AOAC (1995). Total ash was determined as described elsewhere (AOAC, 1995). The crude protein was determined on 0.2g as per micro-Kjeldahl's (AOAC, 1995).

Data obtained were analyzed using the General Linear Model (GLM) of SAS (1988). The following model was used:

$$Y_{ijkl} = \mu + V_i + T_j + G_k + (T * G)_{jk} + (V * T)_{ij} + e_{ijkl},$$

where Y_{ijkl} = weight of dehulled grain or dehulling loss

μ = general mean

V_i = effect of V^{th} sorghum variety

T_j = effect of j^{th} dehulling time

G_k = effect of k^{th} grading size

$(T * G)_{jk}$ = interaction effect between j^{th} dehulling time and k^{th} grading size

$(V * T)_{ij}$ = interaction effect between i^{th} sorghum variety and j^{th} dehulling time

e_{ijkl} = random error

RESULTS AND DISCUSSION

Grading: It was evident that the grains studied had size ranging from 2.0 to 3.5 mm diameter (Table 1). This can have an influence in dehulling losses. Other varieties had fairly large grains comparable to those of the improved varieties (*Tegemeo* and *Pato*). These varieties included *Nkansa, Kalionje, Madibwa, Mboile* and *Msinga wa nyumbu.*

Table 1: Percentage of Grain Sizes in Different Sorghum Varieties

Variety	Sieves size (mm)				
	4.0	3.5	3.0	2.5	2.0
Mngindo	0.00	0.00	69.62	12.38	17.99
Kikombe	0.00	0.39	93.58	3.73	2.32
Mawilu	0.00	0.00	70.60	13.98	15.42
Tegemeo	0.00	38.24	61.76	0.00	0.00
Mbangala 1	0.00	0.00	91.53	4.39	4.08
Songea	0.00	8.14	89.87	0.82	1.17
Pato	0.00	14.60	85.39	0.00	0.00
Mbangala 2	0.00	3.13	93.86	1.12	1.88
Lugugu	0.00	2.19	88.00	5.04	4.77
Nkasa	0.00	46.46	52.04	0.85	0.64
Mboile	0.00	24.17	73.71	1.03	1.09
Msinga wa nyumbu	0.00	20.22	78.73	1.05	0.00
Kalionje	0.00	36.98	62.07	0.36	0.59
Madibwa	0.00	33.29	66.71	0.00	0.00
Udo	0.00	0.00	100.00	0.00	0.00
Kibaha local	0.00	0.00	87.15	2.54	10.31

Effect of Variety, Time and Grading Size on Dehulling Losses of Sorghum

Generally, variation in dehulling time, grading size, interaction between dehulling time and grading size and between dehulling time and sorghum varieties was highly significantly ($P < 0.01$) This influenced the dehulling losses of sorghum.

Effect of Sorghum Varieties on Dehulling Losses

Pooling the results of dehulling losses for different durations of dehulling between 2 and 8 minutes produced the mean dehulling losses. The dehulling losses ranged between 5.7 and 15%, shown in Table 2. Results from Table 2 show that *Mboile* variety had significantly higher dehulling loss ($P<0.05$) compared to the rest of sorghum varieties, followed by *Udo* variety, which had the second higher dehulling loss. The *Madibwa* variety exhibited lowest dehulling loss, which was not significantly different ($P>0.05$) from that of varieties *Pato, Kikombe, Msinga wa nyumbu* and *Tegemeo,* respectively.

Table 2: Effect of Variety of Sorghum on Dehulling Losses

Variety	Mean dehulling loss (%)
Madibwa	5.7^{a}
Pato	6.0^{ab}
Kikombe	6.0^{ab}
Msinga wa nyumbu	6.1^{ab}
Tegemeo	6.2^{ab}
Mngido	6.6^{b}
Mbangala -1	7.8^{c}
Kalionje	8.2^{c}
Lugugu	8.5^{cd}
Songea	8.8^{de}
Kibaha local	9.1^{de}
Nkansa	9.4^{ef}
Mawilu	10.0^{f}
Mbangala -2	10.5^{f}
Udo	11.5^{h}
Mboile	15.0^{i}

Means bearing same superscript are not significantly different ($P> 0.05$)

According to Laswai *et al.* (1998), hardness test of the few varieties of sorghum done suggested that *Lugugu* was the hardest followed by *Pato* and *Udo*, which were soft. From this experiment, *Pato* had lower dehulling losses compared to *Lugugu* although it was not as hard as *Lugugu*. The reason for this might be due to grain size proportion within the variety and probably uniformity of the grains. Table 1 shows that *Pato* variety had grain size range between 3.0 and 3.5 mm while *Lugugu* had grain size range between 2.0 and 3.5 mm, with few grains at size 3.5 mm. Grain size of 3.5 mm had lower dehulling losses (see Table 4). This could account for the higher dehulling losses observed for *Lugugu* variety.

Effect of Dehulling time on Dehulling Losses

Table 3 shows that the dehulling losses increased with dehulling time. At 2 minutes dehulling time, the loss was significantly lower than other dehulling times ($P < 0.05$) and eight minutes dehulling time produced the highest losses.

Table 3 : Effect of Dehulling Time on Dehulling Losses

Time	Mean dehulling loss (%)
2	3.2^{a}
4	8.0^{b}
6	9.8^{c}
8	12.9^{d}

Means bearing same superscript are not significantly different ($P > 0.05$)

Effect of Grading Sizes on Dehulling Losses

Considering the dehulling losses on different grading sizes, the 3.5 mm grain size had significantly lower loss ($P < 0.05$) during dehulling than the other grain sizes (Table 4). However, that loss was not significantly different ($P > 0.05$) from that of 2.5 mm. Also, there were no significant differences in dehulling losses between 3.0, 2.5 and 2.0 mm sizes ($P > 0.05$).

Table 4 : Effect of Grading Size on Dehulling

Grading size (mm)	Mean dehulling loss (%)
3.5	7.6a
3.0	8.6b
2.5	8.1ab
2.0	8.3b
Ungraded	8.1ab

At different dehulling times grading reduced dehulling losses in more than 50% sample except at dehulling time of 6 minutes which showed abnormal results (Table 5).

Table 5: Percentage of Samples which Showed Grading Reduced Dehulling Losses in Different Dehulling Time

Time (minutes)	Graded (%)	Ungraded (%)
2	53.3	46.7
4	75.0	25.0
6	10.0	90.0
8	66.7	33.3

The effect of distribution of different sizes of the grain on dehulling losses for the samples used in this study is shown in Table 6. From this Table, it can be observed that grading reduced losses in more than 80% of the samples, which had the broadest range of the grain size distribution.

Table 6: Percentage of Samples which Showed Grading Reduced Dehulling Losses[1]

Variety	2 minutes		4 minutes	
	Graded (%)	Ungraded (%)	Graded (%)	Ungraded (%)
With one size (n=1)	100.0	0.0	100.0	0.0
With two sizes (n=3)	66.0	34.0	66.7	33.3
With three sizes (n=5)	60.0	40.0	60.0	40.0
With four sizes (n=7)	85.7	14.3	85.0	15.0

n = number of sorghum varieties. [1]Sample grouped in terms of size distribution

As shown in Table 7, protein content in all grains decreased with increasing dehulling time. However, abnormal trend in protein content was shown by the *Mngindo* variety. Ash content also had the same trend except for graded dehulled grains of *Kikombe* and *Madibwa* varieties.

Using the six sorghum varieties used for this part of the study, dehulling seemed to generally reduce protein and ash contents of the resulting grains (Table 7). Similar results have been reported by several authors (Reichert & Young, 1977; Perten, 1977). Losses were also affected by dehulling time as indicated by lower protein and ash content values when dehulling time was increased from 2 to 4 minutes (Table 7). Overall dehulling seemed to have little effect on the ash content of the resulting grains.

Table 7: Mean Proximate Composition Values of the Whole Undehulled Grain Compared with Graded and Ungraded Dehulled Grain from 2 and 4 Minutes Dehulling Time

Variety	Protein content					Ash content				
	0 minutes	2 minutes		4 minutes		0 minutes	2 minutes		4 minutes	
	Whole undehulled	Graded dehulled	Ungraded dehulled	Graded dehulled	Ungraded dehulled	Whole undehulled	Graded dehulled	Ungraded dehulled	Graded dehulled	Ungraded dehulled
Kalionje	15.04	14.87	14.67	14.43	14.27	1.27	1.09	1.21	1.08	1.05
Msinga wa nyumbu	15.75	15.48	15.40	14.78	14.70	1.30	1.30	1.25	1.11	0.98
Mngindo	10.67	10.60	10.50	10.76	10.30	1.46	1.41	1.40	1.24	1.20
Kituli	17.50	16.62	15.75	13.24	13.02	1.22	1.20	1.24	1.10	1.05
Kikombe	14.05	14.17	14.03	9.97	9.62	1.35	1.38	1.25	1.42	1.06
Madibwa	12.66	12.62	12.54	11.37	11.55	1.34	1.37	1.28	1.29	1.15

CONCLUSION

Results have shown that grading of sorghum based on size prior to dehulling proved to reduce dehulling losses by a significant amount in the majority of varieties investigated. The study also revealed that there were other local sorghum varieties that resemble the improved varieties (*Pato* and *Tegemeo*) in terms of grain size distribution. The local varieties were *Madibwa, Kalionje, Nkansa and Mboile*. Dehulling of sorghum is beneficial for improving consumer acceptability of sorghum products. However, excessive dehulling is likely to lead to loss of valuable components, such as protein, ash and minerals.

There was an increase in dehulling loss as the dehulling time was increased. This loss had no uniform trend since it is related to grain size distribution and hardness of the endosperm in each sorghum variety. If grading is to be adopted, there will be a need for agricultural engineers to fabricate a simple grading machine that will be capable of holding a reasonable weight like that usually brought to the mill by households for batch processing. However, for the industrialists who do large-scale processing of sorghum, an appropriate grader to cater for size distribution of varieties that are usually dehulled also seems essential.

From the results of this study, dehulling time should be taken into account during dehulling, since it has shown that extending dehulling time contributes to more dehulling losses. For successful dehulling, hardness of the sorghum is very crucial in setting the dehulling time. In view of variation in losses as influenced by this hardness, appropriate dehulling time needs to be set by the breeder when introducing a new sorghum variety. This may help the processor to perform the dehulling operation more confidently and effectively to maximize yield of grain or flour from this dehulling.

Considering the availability of many sorghum varieties, results obtained in this study cannot be generalized as far as the sorghum processing is concerned. Most studies like this on the other sorghum varieties are needed for a complete assessment and adoption in processing sorghum. The study however did not take into account the effect of grading on fibre content reduction in the food that has an effect on texture, evenness of cooking and nutritional value of the product. Information on this will be important in the 'cookability' and consumer acceptability of the resulting product.

As demonstrated in the quite uniform size distribution of *Tegemeo* and *Pato* varieties on the dehulling without grading, there is a need for breeders to identify the potential local varieties and/or introduce new ones with grains of uniform size.

ACKNOWLEDGEMENTS

The authors wish to thank the Government of Tanzania and the Management of the Sokoine University of Agriculture for their financial, material, moral and logistic support.

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NUTRITIONAL VALUE, SENSORY QUALITY AND ACCEPTABILITY OF CEREAL-BASED WEANING FOODS SUPPLEMENTED WITH *MSHINDI* BEAN FLOUR SARDINES

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ABSTRACT

Low nutrient density in weaning foods is the major cause of under-nutrition among infants and young children in developing countries. Ten types of composite weaning diets namely maize-*mshindi* beans-peanut, maize-peanut-sardines, maize-peanut-sardine-*mshindi* beans, maize-peanut-soaked *mshindi* beans, maize-peanut-germinated *mshindi* beans, sorghum-*Mshindi* beans-peanut, sorghum-peanut-sardines, sorghum-peanut-sardine-*mshindi* beans, sorghum-peanut-soaked *mshindi* beans and sorghum-peanut-germinated *mshindi* beans were formulated and assayed for proximate composition, energy, mineral density, tannin content and residual urease activity. The diets were also evaluated for storage stability under ambient conditions, sensory quality and overall acceptability. Results of the study indicated that concentrations of protein, fat, ash, Ca, Fe, Zn and Cu were significantly ($p \leq 0.05$) increased when plain maize and sorghum gruels were supplemented with *mshindi* beans, peanut paste and/or macerated sardines. Soaking and germinating the *mshindi* beans and dehulling the sorghum reduced the concentration of tannins in the gruels significantly ($p \leq 0.05$). Residual urease activity ranged between 0.00 – 0.07 units, about 10-fold lower than the maximum level (0.8 units) allowed in weaning foods. Both maize and sorghum-based composite gruels had a short shelf life under ambient conditions (26.6^{0}C) ranging between four and six hours, with gruels containing macerated sardines showing a tendency to spoil faster. All composite gruels except those containing germinated *mshindi* beans were highly liked and accepted by consumers ($p \leq 0.05$) similar to the plain maize and sorghum gruels. The maize and sorghum-based composite products therefore have a potential for use as weaning and/or supplementary foods for older infants and young children. Further investigations are suggested to extend the shelf life of the composite products and improve the organoleptic quality of the diets containing germinated *mshindi* beans.

Key words: weaning foods, sensory quality, acceptability, sardines, peanut paste, *mshindi* beans

INTRODUCTION

Under-nutrition during childhood remains a common health problem in many parts of sub-Saharan Africa and makes significant contribution to childhood morbidity and mortality (UN, 1992). In Tanzania, about 50% of young children suffer from protein, energy and micronutrient under-nutrition and more than 0.2 million children are estimated to die before reaching their fifth birthday (Kavishe, 1993; URT-Bureau of Statistics, 1997). The first year of life is usually the vulnerable period for developing under-nutrition, which usually coincides with the introduction of weaning foods. Various studies have shown that children in Tanzania, as is elsewhere in developing countries, start their life in sound health and their growth rate during the first 4 – 6 months is comparable to that of children in developed countries (Mosha *et al.*, 1998; Dewey *et al.*, 1992; URT-UNICEF, 1990). Growth, however, starts to falter during weaning and/or thereafter. Protein, energy and micronutrients deficiencies become a serious problem during this period, as most weaning foods consumed do not supply adequate amount of these nutrients. This period also is accompanied with high incidences of childhood diseases due to increased infections from contaminated weaning foods and decline in the immune related factors acquired from the mother.

The traditional homemade weaning foods of Tanzania are based on starchy staples, usually cereals such as maize (*Zea mays*) and sorghum (*Sorghum bicolor*). Nutritional problems associated with the use of these starch staples in weaning foods have been widely reported (Nout, 1993; Walker, 1990; Seenappa, 1987; Mosha, 1984). Several approaches (Ngoddy *et al.*, 1994) have been suggested to improve the nutritional quality of the weaning foods; including fortifying the cereal-based diets with specific nutrients and/or blending them with other nutrient-rich foods to form composite mixtures. Emphasis has been placed on the use of nutritious, locally produced foods such as beans, lentils and edible fish varieties (e.g. sardines and anchovies) to enrich the starchy foods. Beans (*Phaseolus vulgaris*) have particularly been targeted because they are inexpensive, readily available and contain high amount of protein with high levels of lysine, which can complement the low lysine in cereals. There have been, however, some limitations in the use of dry beans in weaning foods. These include (i) the hard to cook phenomenon of dry beans which makes cooking laborious and time consuming, (ii) the traditional method of cooking dry beans makes it difficult to obtain a soft consistency bean broth that may be incorporated into the weaning gruels (sardines and anchovies have a similar limitation), and (iii) the presence of flatulence producing factors (oligosaccharides). While the latter two limitations have been addressed through improved food processing and preparation techniques such as soaking, germinating, fermenting and pulverizing the dry beans into a fine flour prior to cooking (Ngoddy *et al.*, 1994), the former limitation could be addressed through genetic and breeding selection of bean varieties that cook fast and also display superior sensory and culinary qualities. It is with this objective that the Department of Crop Sciences and Production of the Sokoine University of Agriculture, Tanzania developed a new, fast cooking bean variety called *mshindi*. This bean variety, apart from cooking fast (30 – 40 minutes), it possesses superior brothing and organoleptic qualities that make it suitable for incorporation into weaning foods. This study was conducted to investigate the suitability of utilizing the newly developed *mshindi* bean variety to improve the nutritional quality of maize and sorghum-based weaning mixtures. Sardines and peanuts were also incorporated into the weaning gruels with or without the *mshindi* beans to augment the nutritional values of the diets. Specifically, this study investigated the effect of incorporating whole, soaked or germinated *mshindi* bean flour, peanut paste and/or sun-dried milled sardines into the maize and sorghum-based gruels on the proximate and mineral compositions, storage stability, sensory quality and consumer acceptability of the gruels prepared from the composite flours.

MATERIALS

The weaning food samples used in this study were prepared from maize and sorghum flours blended with peanut paste (*Arachis hypogea*), sun-dried milled sardines (*Sardinops melanosticta*) and/or *mshindi* bean (*Phaseolus vulgaris*) flour. These are food items commonly used in Tanzania for weaning children because they are inexpensive, readily available at the households and easy to prepare. Samples of maize, sorghum, dry sardines, peanuts and sugar were purchased from the Morogoro municipal central market, Tanzania; while the *mshindi* beans were obtained from the Department of Crop Science and Production, Sokoine University of Agriculture, Tanzania.

METHODS

Sample Preparation

The maize and sorghum grains were sorted to remove extraneous matter, washed twice in distilled water and sun-dried for eight hours. The grains were dehulled and then milled into fine (1.0 mm mesh) flour using a commercial hammer mill (Ndume Mills Co., Sussex, UK). The peanuts were sorted, soaked for one hour and washed twice with distilled water to remove the outer brown membranes. The peanuts were then sun-dried for eight hours and roasted in an open pan for 20 minutes at medium heat to develop the characteristic roast flavour. While hot, the peanuts were blended to a paste using a KitchenAid® food processor (Model K45SS, St. Joseph, MI 49085-0558, U.S.A.). The dry sardines were sorted to remove pebbles and other extraneous materials and soaked in a solution of 0.5% $NaHCO_3$ and 1% NaCl for 30 minutes. The soak solution was thereafter decanted and the soak-decant process repeated once. The sardines were thereafter rinsed three times with distilled water, dried and macerated into a fine powder using the KitchenAid® food processor. The soak-decant-washing step was critical because it removed the water-soluble nitrogenous compounds - trimethylamine oxide (TMAO), trimethylamine (TMA) and the fish oil, which cause the characteristic fishy and rancid odours (Suzuki & Watabe, 1987).

The *mshindi* beans were sorted, washed with distilled water and divided into three portions. The first portion was sun-dried for eight hours and milled into fine (1.0 mm mesh) flour. The second portion was soaked in distilled water for four hours, and then washed, sun-dried and ground into fine flour. The third portion was germinated for 36 hours in dark cabinet, then washed with distilled water, sun-dried and ground into fine flour.

The diets were formulated according to WHO/UNICEF (1998) and FAO/WHO (1994) Codex Alimentarius guidelines for cereal-based weaning/follow-up supplementary foods for older infants and young children. The ingredients were combined in proportions that provided the highest amino acid score possible or proportions that met the FAO/WHO/UNU (1985) requirements for energy and essential amino acids (Table 1). The contents for each diet were then used to prepare weaning gruels. The gruels were prepared in the laboratories of the Department of Food Science and Nutrition, Sokoine University of Agriculture, Tanzania following the traditional cooking practices adapted to the laboratory conditions as described by Mosha & Svanberg (1983) and Kikafunda *et al.* (1997). A slight modification was, however, made on the cooking times for the diets containing *mshindi* beans, in which the cooking time was extended from the recommended 15 - 20 min to 35 min.

Chemical Assays

The nutritional composition of the composite gruels was determined according to the standard AOAC (1995) methods. Crude protein was determined by the micro-Kjeldahl method 991.20 using 6.25 as the conversion factor. Crude fibre was determined by acid hydrolysis (method 962.09E) while fat and ash contents were determined by Soxhlet extraction and dry ashing methods, respectively (Methods 945.48B(a), 945.45G and 945.46). Calcium, Mg, Fe, Zn and Cu were determined by atomic absorption spectrophotometry (Pye Unicam Model SP 191, Cambridge, UK) using AOAC (1995) methods 985.35 and 986.24. A single mineral hollow cathode lamp was used for each element. Carbohydrate was determined by difference while gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors - 1g fat = 9 kcal, 1g protein = 4 kcal, 1g carbohydrate = 4 kcal and 1 g alcohol = 7 kcal (Passmore & Eastwood, 1986). The essential amino acid profile of the test diets was compiled from the USDA database [http://www.nal.usda.gov, cited 13th February, 2006] and the amino acid scores determined by comparing the amino acid profile with the FAO/WHO/ UNU (1985) essential amino acid reference pattern for infants (human milk). The percent net dietary protein-energy was computed from the amino acid score using the relationship: Net dietary protein energy % = (1.25 x Protein energy % x Amino acid score)/(100 + 0.064 x Protein energy % x Amino acid score) (Pellet & Mamabranchi, 1979).

Residual urease activity was measured by the change in hydrogen ion concentration as described by Granick (1937) and modified by TBS (1983). Storage stability of the gruels was determined by monitoring total titratable acidity (Nout *et al.*, 1989; Onyango *et al.*, 2000) and the pH (AOAC, 1995). Ten grams of the gruel sample were diluted with 90 ml double distilled water and titrated with 0.1N NaOH. Total titratable acidity of the samples was expressed as percentage lactic acid (w/w) using the relationship:

% Lactic acid = Titre (mL) of NaOH x 0.0090 x 100/weight of sample (g); where 1 ml of 0.1M NaOH = 0.0090 g of lactic acid.

The pH of the gruels was determined by the standard AOAC (1995) procedure using a pH meter (Hanna Instruments, Model 8519, Singapore). Tannin concentration in the gruel samples was determined as catechin equivalents by using the vanillin-HCl assay described by Price *et al.* (1978). All assays were performed in triplicate.

Determination of Viscosity

Viscosity of the gruels was determined by a Brookfield viscometer (Model DVII Rheometer V2.0 RV, Middleboro, MA 02346, U.S.A.) using a method adopted from Mosha and Svanberg (1983). The cooked gruel was poured into the viscometer beaker, cooled to $40^{0}C$ and viscosity measured (in centipoises) using spindle number two at a shear rate of 30 rpm.

Sensory Evaluation

The weaning gruels in identical glass bowls were coded in three-digit numbers for presentation to an untrained test panel of 35 mothers (20 – 38 y) attending the mother and child health (MCH) clinic at Nunge Centre in Morogoro municipality. To avoid panellist fatigue, maize-based and sorghum-based gruels were tested on different days. The panellists were given distilled water in colourless glasses to clear the palate. A five-point hedonic scale whereby (5) and (1) represented the highest and lowest order of preference, respectively, was used as described by Larmond (1977). Attributes evaluated were colour, aroma, taste, texture, and overall acceptability. Lipid oxidation and development of rancidity were evaluated in the stored foods by a small panel of seven mothers who were randomly selected among the large group of panellists involved in testing the gruels. At intervals of every four hours, the stored gruels were presented to the panellists as recommended by Larmond (1997). The panellists were requested to test the gruels and indicate whether they detected rancid or objectionable taste and/or flavour and whether the food was still suitable for consumption. A food was judged unsuitable when four of the seven panellists indicated that the food was unsuitable.

Statistical Analysis

Data were subjected to one-way analysis of variance (ANOVA) where applicable, using the ProStat for Windows® programme, Version 1.6 and a difference was considered to be significant at $p \leq 0.05$.

RESULTS AND DISCUSSION

The proximate composition of the plain and enriched maize and sorghum-based weaning mixtures is shown in Table 2. Protein is an essential macronutrient for the growth and maintenance of body tissues and its requirement is highest during the first year of life (FAO/WHO/UNU, 1985). Incorporation of bean flour, peanut paste and macerated sardines in the basal (plain maize and sorghum) diets increased the protein content of the diets significantly ($p \leq 0.05$). In the maize-based diets, protein content increased by 98, 44, 103, 43 and 42% in MPSr, MPNwh, MPSrNwh, MPNsoak and MPNgerm, respectively. For the sorghum-based diets, protein increments were SPSr (76%), SPNwh (30%), SPSrNwh (76%), SPNsoak (30%) and MPNgerm (29%). Inclusion of milled sardines to the cereal-based diets was nutritionally beneficial because fish have a high quality protein which is more digestible compared to the plant proteins in *mshindi* beans and peanuts (Walker, 1990; Milward, 1999).

Fortification of the maize and sorghum diets with *mshindi* beans, peanut paste and/or ground sardines also increased ($p \leq 0.05$) the fat and ash contents. The increment in fat content ranged between 57 - 177% in maize-based diets and 295 - 759% in sorghum-based diets. For the ash, the increase was 60 - 136% in the maize-based diets and 24 - 80% in sorghum-based diets. The increase in fat content of the diets was mainly attributed to the peanut paste and milled sardines, although a significant amount of the fish oil was extracted out during the processing of the fish. The level of ash in food is an important nutritional indicator for mineral density and also a quality parameter for contamination, especially with foreign matter e.g. pebbles (Fennema, 1996). Fibres have been reported to increase dietary bulkiness, hence limiting adequate food intake by infants and young children (Hofvander & Underwood, 1987). FAO (1985) Codex Committee recommended that weaning foods should not contain more than 5g of crude fibre per 100g of dry edible matter. The crude fibre contents of our diets were in the range of 2.03 - 2.99g/100g in the maize-based diets and 2.01 - 2.88g/100g in the sorghum-based diets, lower than the amount (5g/100g) recommended by the FAO (1985) Codex Committee for weaning foods.

Low energy density in weaning foods has been pointed out as a major cause of poor growth and under-nutrition among children in developing countries (Walker, 1990). Formulation of composite food mixtures containing cereal, legumes, oilseeds and animal products has been proposed as the most practical and sustainable approach for improving the energy, protein, macro- and micro-nutrient status of weaning foods in developing countries (Pellett & Mamabranchi, 1979). Enrichment of maize and sorghum gruels with peanut paste, *mshindi* beans and/or ground sardines significantly improved ($p \leq 0.05$) their energy densities (Table 2). The energy density increased by 0.5 - 4.0% in the maize-based diets and 0.8 - 4.8% in the sorghum-based diets. The energy densities of the composite gruels in this study were comparable to those recommended in foods for older infants and young children (Cameron & Hofvander, 1976; Pellett & Mamabranchi, 1979). High dietary energy is essential for sparing protein from being utilized as a source of energy. It is recommended that, in order for the dietary protein to be used for the intended purpose of building and repairing body tissues, the proportion of protein to energy in the weaning foods must not be less than 15% (Cameron & Hofvander, 1976; Pellett & Mamabranchi, 1979). The percent of protein-energy in our composite diets ranged from 15.0% in MPNsoak to 21.1% in MPSrNwh (maize-based diets) and 17.7% in SPNgerm to 22.9% in SPSrNwh (sorghum-based diets). The percent of protein-energy in both plain maize (10.5%) and sorghum (13.4%) were significantly lower ($p > 0.05$) than the level ($\geq$ 15%) recommended by the UN-Protein-Calorie Advisory Group (Cameron & Hofvander, 1976; Pellett & Mamabranchi, 1979).

Viscosities of the gruels prepared at a solid concentration of 7% (w/v) were in the range of 1783 - 2178 cP in the maize-based diets and 553 - 1175 cP in the sorghum-based diets. These viscosities were lower or within the range 1000 - 3000 cP suggested by Mosha and Svanberg (1983) to be suitable for older infants and young children. This implied that our composite diets could be prepared at higher solid concentrations of up to 10 - 15% (w/v) without exceeding the upper viscosity limit (3000 cP). As reported in other studies (Mosha & Svanberg, 1983; Svanberg & Taal, 1985) addition of germinated *mshindi* beans in the maize and sorghum gruels resulted in significant ($p \leq 0.05$) reduction in their viscosities. The viscosity of the maize diet blended with germinated *mshindi* beans (MPNgerm, 1783 cP) was 18% lower than that of a similar diet blended with ungerminated *mshindi* beans (MPNwh, 2168 cP). For the sorghum diet fortified with germinated *mshindi* beans (SPNgerm, 888 cP), the viscosity was 24% lower than that of a similar diet blended with ungerminated *mshindi* beans (SPNwh, 1175 cP). Germinating cereal and legume grains has been reported to reduce dietary bulk (viscosity) in weaning gruels, enabling children to take more dry matter at the same semi-liquid consistency (Nout, 1993). High dietary bulk limits nutrient intake in infants and young children and thus contributes directly to protein, energy and micronutrient under-nutrition (Ljungqvist *et al.*, 1981).

Table 3 presents the mineral concentrations of the various maize and sorghum-based diets. Supplementation of the maize and sorghum diets with peanut paste, *mshindi* beans and/or macerated sardines improved the Ca concentrations significantly ($p \leq 0.05$). Blending increased the concentration of Ca by 287 - 718% (18.10 - 148.48 mg/100 g) in the maize-based diets and 122 - 305% (39.20 - 158.73 mg/100g) in the sorghum-based diets. The Ca levels observed in the composite gruels were comparable to those reported in other studies (Mugula & Lyimo, 1999; Mosha *et al.*, 2000). Calcium is particularly essential for infants and young children for building up bones and teeth, muscles and nerves functioning, blood clotting and for immune defence (Whitney *et al.*, 1990).

Magnesium concentrations were not improved ($p > 0.05$) by the fortification of both maize and sorghum diets with peanut paste, *mshindi* beans and/or milled sardines. Magnesium concentrations were in the range of 163.60 - 175.31 mg/100g in the maize-based diets and 170.33 - 186.20 mg/100g in the sorghum-based diets. For Na, enrichment reduced its concentration in some of the diets; however, it was significantly ($p \leq 0.05$) increased in the diets that were blended with ground sardines. Sodium concentrations ranged between 29.20 - 227.28mg/100g in the maize-based composite diets and 36.18 - 235.86mg/100g in the sorghum-based diets. The concentrations of Na in all the diets were nonetheless within the recommended levels (96.78 - 411.32 mg/100g) for weaning foods (FAO/WHO, 1994). Modest concentrations of Na are recommended for infants and young children foods to reduce the risk of renal solute overload (Ziegler & Fomon, 1971). A potential link has also been postulated between high Na intake in childhood and occurrence of hypertension in later life, but the evidence is still elusive (Kerr *et al.*, 1987).

Iron and Zn are essential micronutrients for the growth of infants and young children. Iron plays a unique role in the synthesis of haemoglobin and myoglobin while Zn plays an important role in the synthesis of hormones, proteins and other materials that promote optimal physical and mental growth. Both Zn and Fe are also involved in the synthesis of enzymes and co-enzymes and in enhancing the body's immune integrity (Hambridge, 1986; Whitney *et al.*, 1990, Winzerling & Law, 1997). Addition of peanut paste, *mshindi* beans and/or milled sardines did not improve ($p > 0.05$) the concentrations of Fe in the maize-based composite diets. For the sorghum-based diets, there was a significant increase ($p \leq 0.05$) in Fe concentrations for the diets containing milled sardines (Table 3). Iron concentration in the maize-based diets ranged from 7.68mg/100g in MPNgerm to 8.86mg/100g in plain maize gruel. For the sorghum-based diets, Fe concentrations ranged from 5.56 mg/100g in SPNgerm to 6.21 mg/100g in SPSrNwh. The levels of Fe observed in this study were comparable to those reported from other studies (Mosha *et al.*, 2000). Zinc concentrations were significantly higher ($p \leq 0.05$) in the maize and sorghum-based diets that were enriched with milled sardines. Addition of ground sardines to the basal diets was therefore helpful in improving the Fe and Zn status of the diets.

Copper is involved in the absorption and utilization of Fe during haemoglobin and myoglobin synthesis and forms part of several enzymes (Winzerling & Law, 1997). Copper concentration was significantly higher ($p < 0.05$) in both maize and sorghum-based composite diets compared to the plain gruels. Percent increase in Cu concentrations due to addition of peanut paste, *mshindi* beans and/or milled sardines ranged between 19 - 34% (0.47 - 0.63mg/100g) in maize-based diets and 22 - 44% (0.41 - 0.59mg/100g) in sorghum-based composite diets. Increased dietary intake of Cu along with Fe in the weaning foods may have a beneficial effect of enhancing Fe uptake and utilization. This may conversely reduce the high prevalence of iron-deficiency anaemia among pre-school age children in Tanzania (Kavishe, 1993).

When consumed in adequate amounts, all the composite diets could provide adequate amount of the recommended daily allowances for Mg, Zn, Fe and Cu. According to Mosha and Svanberg (1990), the average intakes of gruels containing 20% solid matter in rural communities were 277g (55.4g dry matter), 405g (81g dry matter) and 517g (103.4g dry matter) for children aged 1- 2, 3 - 4 and 5 - 6 years, respectively. With an average intake of 3 - 4 meals per day, the total solid matter taken would be 166.2 - 221.6, 243 - 324, and 310.2 - 413.6g per day for children aged 1- 2, 2 - 4 and 4 - 5 years, respectively. At this level of food intake, the diets could meet 100% of RDA for Mg, 97 - 100% of RDA for Zn, 100% of RDA for Cu, 100% of RDA for Fe and 40 - 60% of the RDA for Ca. The recommended dietary allowances for Ca, Mg, Zn, Fe, and Cu for children aged 1- 6 years are 500 - 600 mg, 60 - 73 mg, 4.1 - 5.1 mg, 6 - 9 mg, and 0.34 - 0.44 mg, respectively (FAO/WHO, 2001; FNB-IOM, 2001).

Table 4 presents the changes in pH and total titratable acidity of the various diets during the storage period. For both maize and sorghum-based diets, storage at ambient temperatures (~ 26.4^{0}C) for up to four hours did not result in significant change ($p > 0.05$) in the pH. Significant decreases in the pH were observed in the diets containing macerated sardines and peanut paste after eight hours of storage. In the first eight hours, pH decreased by an average of 11% in the maize and 10% in the sorghum diets enriched with peanut paste and macerated sardines. In the diets blended with peanut paste and *mshindi* beans, the pH decreased by an average of 4 and 9% for the maize-bean and sorghum-bean composite diets, respectively. The decrease in the pH could be due to lactic fermentation of the starch in the gruels by *Lactobacillus spp* to produce lactic acid (Nout *et al.*, 1989; Onyango *et al.*, 2000). The decline in the pH of the diets during storage was echoed on the increase in the total titratable acidity. In the first eight hours of storage, there was no significant ($p > 0.05$) increase in the total titratable acidity of the diets containing *mshindi* beans, except those blended with peanut paste and macerated sardines. Between eight and sixteen hours of storage, there was a rapid increase ($p \leq 0.05$) in the concentration of total acidity in all the diets, with the highest levels being in the diets blended with peanut paste and ground sardines. Despite these changes in the total acidity and the pH, none of the gruels was reported to have undergone rancidity. The decrease in the pH and increase in total acidity have been pointed out as the major causes for retrogradation in gruels, a physical-chemical phenomenon characterized by shrinkage of starch and oozing of fluid from the food mass (Fennema, 1996). Retrogradation is traditionally regarded by the local people in Tanzania as a sign of food spoilage.

Physical examinations of the stored diets revealed that maize-based diets started to undergo retrogradation during the fifth hour while, the sorghum-based diets showed the early signs of retrogradation during the sixth hour. Maize and sorghum-diets containing peanut paste and macerated sardines were fully retrograred by the end of the sixth hour while all other diets were fully retrograded by the end of the eighth hour. In light of these observations, the shelf life of these homemade composite diets under the ambient conditions (ca. 26.6^0C) was only four to five hours for maize-based diets and six to seven hours for the sorghum-based diets. Incorporation of macerated sardines therefore increased the susceptibility of the gruels to spoilage and tended to shorten their shelf life. It is worth noting here that, rejection of the stored gruels was solely based on the development of retrogradation because none of the gruels development detectable rancid flavour during the entire storage period of 16 hours. The short shelf life of the cooked gruels compels the mothers to cook meals several times in a day to be able to provide fresh gruels to their children. Considering the mother's high workload and the other competing constrains such as time, fuelwood and water, mothers are often obliged to feed the retrograded (spoiled) food to their children (Bary, 1980; Wandel & Holmboe-Ottesen, 1992). This calls for the need to process these composite mixtures into fully cooked, dehydrated ready-to-eat-type products that would require only reconstitution with hot water prior to feeding.

Tannins are antinutritional factors that react with protein in foods to form insoluble complexes. They also chelate Fe making it unavailable for absorption. Tannins therefore lower the overall quality of foods by reducing bio-availability of protein and Fe. Tannin concentrations of the plain and composite diets are summarized in Table 5. Tannins concentrations were significantly lower ($p > 0.05$) in the plain maize gruel than in the composite gruels. Soaking the *mshindi* beans and discarding the soak water, germinating, and dehulling the sorghum grains were techniques used in this study to reduce the tannin concentrations. As shown in Table 5, diets that were blended with soaked *mshindi* beans contained significantly lower levels ($p > 0.05$) of tannins compared to those blended with unsoaked *mshindi* beans (MPNsoak – 25.43 mg/100g vs. MPNwh - 35.16mg/100g and SPNsoak - 53.98mg/100g vs. SPNwh - 79.23mg/100g). Likewise, the diets blended with germinated *mshindi* beans contained lower ($p > 0.05$) concentrations of tannins than those blended with ungerminated *mshindi* beans. The maize-based diet enriched with germinated *mshindi* beans (MPNgerm, 22.97mg/100g) contained 37% less tannins compared to the diet blended with whole *mshindi* beans (MPNwh, 35.16 mg/100g) while the sorghum diets mixed with germinated *mshindi* beans (SPNgerm, 51.99 mg/100g) contained 33% less tannins than the diets blended with ungerminated *mshindi* beans (SPNwh, 79.23mg/100g). This decrease in tannin concentrations for diets blended with germinated *mshindi* beans was in agreement with findings of other studies (Chavan & Kadam, 1989). In a study of fava beans (*Vicia faba*), kidney beans (*Phaseolus vulgaris*) and red sorghum, Chavan and Kadam (1989) observed that germination reduced not only the concentration of tannins but also of other anti-nutritional factors (phytohemagglutinins and phytic acid). The decrease in tannin concentrations was attributed to the interactions between tannins and proteins, enzymes and other organic compounds during germination to form complexes, which reduces the assayable tannins (Chavan & Kadam, 1989). The tannin levels observed in this study were comparable to those reported in other studies to be safe (Al-Kahtani, 1995; Mugula & Lyimo,

1999) and were therefore not considered to cause any adverse nutritional effect.

Improperly cooked beans have been reported to cause gastrointestinal problems in children such as diarrhoea, vomiting and stomach pains (Korte, 1972). Proper cooking of beans is also essential to improve flavour, increase protein and starch digestibility and inactivate antinutritional factors (e.g. trypsin and chymotripsin) and toxins (e.g. phytohemagglutinins). Completeness of cooking in beans and bean-cereal mixtures is determined by the residual level of urease enzyme after cooking (TBS, 1983). According to the Tanzania Bureau of Standards (1983) weaning foods containing legumes must not contain more than 0.8 units of urease activity. Table 5 presents the residual urease activity units for the various maize and sorghum-based diets. In the maize-based diets, urease activity ranged between 0.00 - 0.05 units while in the sorghum-based diets urease activity ranged between 0.03 - 0.08 units. The residual levels of urease enzyme in our diets were therefore ten-fold lower that the recommended level (0.8 units); suggesting that, the foods were fully cooked and safe for consumption by children.

Data on the sensory evaluation and acceptability of the maize and sorghum-based weaning gruels by mothers are presented in Table 6. Consumers liked the colour, aroma, taste and texture of the composite diets containing peanut paste and macerated sardines (MPSr, MPSrNwh, SPSr and SPSrNwh) more than ($p \leq 0.05$) the plain and/or the composite diets containing peanut paste and *mshindi* beans. It was interesting to observe that, acceptability was highest among the composite diets that contained macerated sardines. This could probably be due to the way the sardines were processed to remove the offending fishy and rancid odours. This procedure has been reported to be useful in removing the fishy and rancid odours in pelagic small fish e.g. sardines, enabling them to be used in a variety of food products (Suzuki & Watabe, 1987).

MPNgerm and SPNgerm were the least liked diets. Their mean rating scores for colour, aroma, and taste were significantly lower ($p > 0.05$) than those of the basal diets (MZ and SG). Although blending of maize and sorghum gruels with germinated *mshindi* showed significant benefits in reducing the viscosity and the level of tannins in the gruels, it however, adversely affected the aroma, taste and overall acceptability of the diets. Results of some acceptability studies by Marrero *et al.* (1988a; 1988b) using germinated mungbeans and cowpeas showed that consumer acceptability was high when the gruels were flavoured with various agents such as artificial fruit flavours, vanilla, chocolate and ginger. Acceptability could have probably been greatly increased if flavours would have been added to our gruels. Considering the nutritional benefits associated with the use of germinated cereals/legumes in the weaning foods, there is a need to investigate on some local flavour agents that may be used to improve the sensory quality of the diets especially those containing germinated *mshindi* beans. In terms of overall acceptability, all the composite diets except those blended with germinated *mshindi* were just as acceptable as the traditional weaning diets made from plain MZ and SG. For the diets containing germinated *mshindi* beans, organoleptic qualities were objectionable and consumers would accept the food only when hungry.

Table 7 presents the comparison of the energy density, percent protein energy, net dietary protein-energy value (NDpE%) and organoleptic quality of the maize and sorghum-based composite diets with the UN - Protein-Calorie Advisory Group (UN-PAG) recommendations for homemade weaning foods. All composite diets contained high energy density above 350kcal/100g, protein energy percent $\simeq$ 15g/100g and NDpE% within or above the recommended range (6 - 8%) (Cameron & Hofvander, 1976; Pellett & Mamabranchi, 1979). The plain gruels made from maize and sorghum and which are traditionally used as weaning foods, could not meet the UN-PAG recommendations. Organoleptically, all the diets except those containing germinated *mshindi* beans were acceptable by consumers. According to FAO/WHO (1994), weaning foods must contain adequate amount of high quality protein, high energy density, must be free of anti-nutritional factors and toxins, should be formulated from locally produced, easily accessible inexpensive food materials and must be culturally and organoleptically acceptable by adults and children. In light of the foregoing, the maize and sorghum-based composite diets have a high potential for use as weaning and/or supplementary foods in Tanzania. There is, however, a need to improve the taste and aroma of the diets containing germinated *mshindi* beans, to make them more appealing to consumers.

CONCLUSION

This study showed that supplementing maize and sorghum diets with *mshindi* beans, peanut paste and/or macerated sardines increased the protein content, percent protein energy, fat, ash, Ca, Fe, Zn and Cu concentrations. Storage stability of the maize/sorghum composite gruels under ambient conditions was four to six hours. Organoleptically, all composite gruels except those containing malted/germinated *mshindi* beans were as good and acceptable by adults as the traditional gruels prepared from plain maize or sorghum. Despite affecting the consumer preference for aroma, taste and overall acceptability, germination was beneficial in reducing the viscosity and the level of tannins in the blended gruels. The maize and sorghum composite diets therefore have a high potential for use as weaning and/or supplementary foods for older infants and young children. There is however a need to conduct further studies on the possibility of extending the shelf life of the composite mixtures by producing fully cooked, dehydrated, ready-to-eat type products and also device some ways to improve the sensory qualities and acceptability of the diets supplemented with germinated *mshindi* beans.

ACKNOWLEDGEMENTS

We are grateful to the mothers and nurses who participated in this study. We are also very grateful to the United States Agency for International Development for supporting this study through the Bean/Cowpea Collaborative Research Support Programme (CRSP), East, Central and Southern Africa region.

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Table 1: Composition (g/100 g) of the Plain and Composite Maize/Sorghum - *Mshindi*/Sardine/Peanut Gruels[1,2]

Ingredient/Diet[1]	MZ	MPSr	MPNwh	MPSrNwh	MPNsoak	MPNgerm	SG	SPSr	SPNwh	SPSrNwh	SPNsoak	SPNgerm
Maize	98	78	68	58	68	68	-	-	-	-	-	-
Sorghum	-	-	-	-	-	-	98	78	68	58	68	68
Sugar	2	2	2	2	2	2	2	2	2	2	2	2
Peanut	-	5	5	5	5	5	-	5	5	5	5	5
Sardines	-	15	-	10	-	-	-	15	-	10	-	-
Mshindi beans												
Whole	-	-	25	25	-	-	-	-	25	25	-	-
Soaked	-	-	-	-	25	-	-	-	-	-	25	-
Germinated	-	-	-	-	-	25	-	-	-	-	-	25
TOTALS	100	100	100	100	100	100	100	100	100	100	100	100

[1] MZ = maize - plain, MPSr = maize - peanut - sardine, MPNwh = maize - peanut - whole *mshindi*, MPSrNwh = maize - peanut - sardine - whole *mshindi*, MPNsoak = maize - peanut - soaked *mshindi*, MPNgerm = maize - peanut - germinated *mshindi*, SG = sorghum - plain, SPSr = sorghum - peanut - sardine, SPNwh = sorghum - peanut - whole *mshindi*, SPSrNwh = sorghum - peanut - sardine - whole *mshindi*, SPNsoak = sorghum - peanut - soaked *mshindi*, SPNgerm = sorghum - peanut - germinated *mshindi*.

[2] Diets formulated according to WHO/UNICEF (1998) and FAO/WHO (1994) Codex Alimentarius and guidelines for cereal-based weaning/follow-up supplementary foods for older infants and young children. Ingredients combined to attain the highest amino acid score possible or in proportions that met the FAO/WHO/UNU (1985) requirements for energy and essential amino acids.

Maize/Sorghum - *Mshindi*/Sardine/Peanut Gruels[1]

Diet[2]	Crude protein	Carbohydrate	Crude fat	Crude Fiber	Ash	Energy	Protein-energy	Viscosity
Maize-based diets								
MZ	10.45 ± 0.17^{c}	83.39 ± 0.99^{a}	2.41 ± 0.32^{d}	2.38 ± 0.30^{a}	1.37 ± 0.10^{f}	397.1 ± 1.2^{b}	10.5 ± 0.4^{d}	2178 ± 33^{a}
MPSr	20.87 ± 0.27^{a}	67.35 ± 0.64^{c}	6.67 ± 0.56^{a}	2.11 ± 0.31^{ab}	3.00 ± 0.01^{b}	413.0 ± 0.5^{a}	20.2 ± 0.3^{b}	1992 ± 26^{b}
MPNwh	15.17 ± 0.81^{b}	75.39 ± 0.44^{b}	4.16 ± 0.30^{c}	2.99 ± 0.11^{a}	2.29 ± 0.13^{e}	400.3 ± 1.0^{a}	15.1 ± 0.5^{c}	2168 ± 25^{a}
MPSrNwh	21.38 ± 0.19^{a}	66.98 ± 0.99^{c}	5.55 ± 0.30^{b}	2.65 ± 0.02^{a}	3.44 ± 0.02^{a}	404.2 ± 1.9^{a}	21.1 ± 0.0^{a}	2160 ± 31^{a}
MPNsoak	15.06 ± 0.55^{b}	75.61 ± 0.36^{b}	3.87 ± 0.39^{c}	2.69 ± 0.00^{a}	2.77 ± 0.10^{c}	399.0 ± 1.0^{b}	15.0 ± 0.2^{c}	2010 ± 29^{b}
MPNgerm	14.99 ± 0.10^{b}	76.62 ± 0.41^{b}	3.78 ± 0.01^{c}	2.03 ± 0.11^{b}	2.58 ± 0.01^{d}	401.2 ± 1.3^{a}	14.8 ± 0.4^{c}	1783 ± 25^{c}
Sorghum-based diets								
SG	12.91 ± 0.10^{c}	81.84 ± 0.29^{a}	0.67 ± 0.03^{d}	2.59 ± 0.11^{a}	1.99 ± 0.11^{e}	385.1 ± 1.2^{d}	13.4 ± 0.3^{c}	713 ± 17^{d}
SPSr	22.74 ± 0.17^{a}	66.38 ± 0.70^{c}	5.21 ± 0.05^{a}	2.21 ± 0.02^{b}	3.46 ± 0.03^{b}	403.6 ± 1.6^{a}	22.7 ± 0.3^{a}	553 ± 19^{e}
SPNwh	16.99 ± 0.03^{b}	74.44 ± 0.54^{b}	2.91 ± 0.12^{c}	2.97 ± 0.18^{a}	2.69 ± 0.06^{c}	388.1 ± 1.3^{d}	17.8 ± 0.0^{b}	1175 ± 21^{a}
SPSrNwh	22.78 ± 0.32^{a}	66.49 ± 0.56^{c}	4.49 ± 0.09^{b}	2.68 ± 0.11^{a}	3.56 ± 0.09^{a}	397.3 ± 1.7^{b}	22.9 ± 0.2^{a}	1134 ± 30^{a}
SPNsoak	16.86 ± 0.43^{b}	75.02 ± 0.78^{b}	2.67 ± 0.52^{c}	2.89 ± 0.00^{a}	2.56 ± 0.01^{d}	391.7 ± 0.9^{c}	17.2 ± 0.7^{b}	1098 ± 24^{b}
SPNgerm	16.80 ± 0.31^{b}	75.74 ± 0.69^{b}	2.51 ± 0.40^{c}	2.11 ± 0.41^{b}	2.84 ± 0.01^{c}	393.1 ± 1.8^{c}	17.1 ± 0.3^{b}	888 ± 14^{c}

[1] Values are means ± SD based on triplicate analyses. Values in a column of a diet group with different superscripts are significantly different at $p \leq 0.05$.

[2] MZ = maize - plain, MPSr = maize - peanut - sardine, MPNwh = maize - peanut - whole *mshindi*, MPSrNwh = maize - peanut - sardine - whole *mshindi*, MPNsoak = maize - peanut - soaked *mshindi*, MPNgerm = maize - peanut - germinated *mshindi*, SG = sorghum - plain, SPSr = sorghum - peanut - sardine, SPNwh = sorghum - peanut - whole *mshindi*, SPSrNwh = sorghum - peanut - sardine - whole *mshindi*, SPNsoak = sorghum - peanut - soaked *mshindi*, SPNgerm = sorghum - peanut - germinated *mshindi*.

Table 3: Mineral Contents (mg/100 g) of the Plain and Composite Maize/Sorghum - *Mshindi*/Sardine/Peanut Gruels[1]

Nutrimt/Diet[2]	Na	Ca	Mg	Fe	Zn	Cu
Maize-based diets						
MZ	38.22 ± 0.30^{c}	18.10 ± 0.11^{e}	175.31 ± 0.30^{a}	8.86 ± 0.10^{a}	2.62 ± 0.01^{b}	0.47 ± 0.00^{b}
MPSr	227.28 ± 0.70^{a}	132.10 ± 0.71^{b}	164.66 ± 0.79^{d}	8.51 ± 0.03^{b}	3.21 ± 0.07^{a}	0.56 ± 0.01^{a}
MPNwh	29.20 ± 0.80^{f}	72.12 ± 0.32^{c}	171.48 ± 0.70^{b}	8.71 ± 0.01^{c}	2.80 ± 0.18^{b}	0.58 ± 0.00^{a}
MPSrNwh	155.73 ± 0.90^{b}	148.48 ± 0.90^{a}	163.60 ± 0.80^{e}	8.61 ± 0.04^{c}	3.27 ± 0.03^{a}	0.68 ± 0.09^{a}
MPNsoak	35.65 ± 0.69^{d}	69.96 ± 0.40^{d}	168.56 ± 0.30^{b}	8.09 ± 0.06^{c}	2.65 ± 0.12^{b}	0.67 ± 0.00^{a}
MPNgerm	33.51 ± 0.84^{e}	70.61 ± 0.67^{d}	171.01 ± 0.44^{c}	7.08 ± 0.00^{d}	2.49 ± 0.10^{c}	0.60 ± 0.06^{a}
Sorghum-based diets						
SG	49.00 ± 0.90^{c}	39.20 ± 0.30^{f}	186.20 ± 1.01^{a}	5.81 ± 0.44^{b}	2.48 ± 0.00^{d}	0.41 ± 0.08^{c}
SPSr	235.86 ± 0.14^{a}	149.69 ± 0.40^{b}	173.27 ± 0.73^{d}	6.09 ± 0.08^{a}	3.10 ± 0.01^{a}	0.52 ± 0.02^{b}
SPNwh	36.18 ± 0.47^{f}	87.00 ± 0.12^{e}	178.10 ± 0.89^{b}	6.05 ± 0.00^{a}	2.63 ± 0.06^{c}	0.57 ± 0.01^{ba}
SPSrNwh	162.48 ± 0.25^{b}	158.73 ± 0.30^{a}	170.33 ± 0.73^{e}	6.21 ± 0.08^{a}	3.04 ± 0.03^{b}	0.59 ± 0.02^{a}
SPNsoak	42.35 ± 0.80^{d}	90.34 ± 0.22^{c}	171.00 ± 1.10^{e}	5.60 ± 0.09^{c}	2.21 ± 0.04^{e}	0.51 ± 0.00^{b}
SPNgerm	39.53 ± 0.88^{e}	88.23 ± 0.73^{d}	176.04 ± 0.83^{c}	5.56 ± 0.03^{c}	2.42 ± 0.03^{d}	0.55 ± 0.01^{ba}

[1] Values are means ± SD based on triplicate analyses. Values in a column of a diet group with different superscripts are significantly different at $p \leq 0.05$.

[2] MZ = maize - plain, MPSr = maize - peanut - sardine, MPNwh = maize - peanut - whole *mshindi*, MPSrNwh = maize - peanut - sardine - whole *mshindi*, MPNsoak = maize - peanut - soaked *mshindi*, MPNgerm = maize - peanut - germinated *mshindi*, SG = sorghum - plain, SPSr = sorghum - peanut - sardine, SPNwh = sorghum - peanut - whole *mshindi*, SPSrNwh = sorghum - peanut - sardine - whole *mshindi*, SPNsoak = sorghum - peanut - soaked *mshindi*, SPNgerm = sorghum - peanut - germinated *mshindi*.

Table 4: Changes in pH and Total Titratable Acidity of the Plain and Composite Maize/Sorghum - *Mshindi*/Sardine/Peanut Gruels[1]

Holding time (hr)/Diet[2]	MZ	MPSr	MPNwh	MPSrNwh	MPNsoak	MPNgerm	SG	SPSr	SPNwh	SPSrNwh	SPNsoak	SPNgerm
pH												
0	5.7^a	6.8^a	5.8^a	6.3^a	5.5^a	5.9^a	6.4^a	6.8^a	6.7^a	6.9^a	6.6^a	6.5^a
4	5.6^a	6.4^b	5.6^a	5.9^{ab}	5.4^a	5.8^a	6.3^a	6.5^{ab}	6.2^{ab}	6.7^a	6.3^a	6.1^a
8	5.6^{ab}	6.1^c	5.5^a	5.5^b	5.2^a	5.6^{ab}	6.3^a	6.3^b	5.8^b	6.0^b	5.9^a	5.9^{ab}
12	5.4^c	5.0^d	5.3^b	5.2^c	5.0^b	5.5^{bc}	6.2^a	5.6^c	5.4^{bc}	5.2^c	5.8^a	5.6^{bc}
16	5.4^{bc}	4.3^e	5.3^b	4.7^d	5.0^b	5.4^c	5.8^b	5.4^c	5.3^c	4.9^c	5.0^b	5.2^c
Total titratable acidity (g/100ml)												
0	0.108^a	0.110^a	0.116^a	0.114^a	0.118^a	0.168^a	0.072^a	0.095^a	0.113^a	0.127^a	0.144^a	0.145^a
4	0.116^a	0.126^{ab}	0.122^a	0.123^a	0.124^a	0.174^{ab}	0.080^{ab}	0.131^b	0.118^a	0.131^a	0.144^a	0.155^a
8	0.125^a	0.136^b	0.128^a	0.138^b	0.125^a	0.179^{ac}	0.094^b	0.157^c	0.120^a	0.161^b	0.152^a	0.170^b
12	0.170^b	0.214^c	0.203^b	0.186^c	0.178^b	0.189^{bc}	0.108^c	0.189^d	0.136^b	0.188^c	0.169^b	0.196^c
16	0.242^c	0.339^d	0.278^c	0.213^d	0.206^c	0.205^d	0.138^d	0.211^e	0.147^c	0.215^d	0.194^c	0.223^d

[1] Values in a column of a diet group with different superscripts are significantly different at $p \leq 0.05$.

[2] MZ = maize - plain, MPSr = maize - peanut - sardine, MPNwh = maize - peanut - whole *mshindi*, MPSrNwh = maize - peanut - sardine - whole *mshindi*, MPNsoak = maize - peanut - soaked *mshindi*, MPNgerm = maize - peanut - germinated *mshindi*, SG = sorghum - plain, SPSr = sorghum - peanut - sardine, SPNwh = sorghum - peanut - whole *mshindi*, SPSrNwh = sorghum - peanut - sardine - whole *mshindi*, SPNsoak = sorghum - peanut - soaked *mshindi*, SPNgerm = sorghum - peanut - germinated *mshindi*.

Table 5: Tannin Content and Urease Activity of the Plain and Composite Maize/Sorghum-*Mshindi*/Sardine/Peanut Gruels[1]

Diet[2]	Tannin (mg/100g)	Urease activity (Units)
Maize based diets		
MZ	3.00 ± 0.02^{e}	0.01 ± 0.00^{d}
MPSr	13.00 ± 1.04^{d}	0.00 ± 0.00^{e}
MPNwh	35.16 ± 1.77^{a}	0.05 ± 0.01^{a}
MPSrNwh	33.99 ± 1.10^{b}	0.03 ± 0.01^{b}
MPNsoak	25.43 ± 0.89^{c}	0.02 ± 0.00^{d}
MPNgerm	22.97 ± 1.32^{c}	0.03 ± 0.00^{c}
Sorghum-based diets		
SG	84.40 ± 2.05^{a}	0.06 ± 0.02^{a}
SPSr	70.52 ± 1.79^{c}	0.04 ± 0.00^{b}
SPNwh	79.23 ± 2.08^{b}	0.08 ± 0.01^{a}
SPSrNwh	81.41 ± 1.03^{b}	0.06 ± 0.01^{b}
SPNsoak	53.98 ± 0.98^{d}	0.04 ± 0.01^{b}
SPNgerm	51.99 ± 1.00^{e}	0.03 ± 0.00^{c}

[1] Values are means $\pm$ SD based on triplicate analyses. Values in a column of a diet group with different superscripts are significantly different at $p \leq 0.05$.

[2] MZ = maize - plain, MPSr = maize - peanut - sardine, MPNwh = maize - peanut - whole *mshindi*, MPSrNwh = maize - peanut - sardine - whole *mshindi*, MPNsoak = maize - peanut - soaked *mshindi*, MPNgerm = maize - peanut - germinated *mshindi*, SG = sorghum - plain, SPSr = sorghum - peanut - sardine, SPNwh = sorghum - peanut - whole *mshindi*, SPSrNwh = sorghum - peanut - sardine - whole *mshindi*, SPNsoak = sorghum - peanut - soaked *mshindi*, SPNgerm = sorghum - peanut - germinated *mshindi*.

Table 6: Acceptability of the plain and composite maize and sorghum gruels[1]

Diet[2]	Mean rating				
	Color	Aroma	Taste	Texture	Overall Acceptability
Maize based gruel					
MZ	4.10[c]	4.15[b]	4.55[b]	4.45[a]	5.00[a]
MPSr	5.00[a]	4.98[a]	5.00[a]	4.50[a]	5.00[a]
MPNwh	4.60[b]	4.10[b]	4.01[c]	4.35[b]	4.00[b]
MPSrNwh	5.00[a]	4.91[a]	4.81[ba]	4.90[a]	4.60[a]
MPNsoak	3.90[d]	3.95[b]	4.55[b]	4.50[d]	3.88[b]
MPNgerm	3.50[e]	2.95[c]	3.65[c]	4.10[b]	3.00[c]
Sorghum-based gruel					
SG	4.30[b]	4.25[b]	4.85[a]	4.25[b]	4.96[a]
SPSr	4.86[a]	4.80[a]	4.70[a]	4.85[a]	5.00[a]
SPNwh	4.35[b]	4.30[b]	3.90[b]	4.42[b]	4.60[b]
SPSrNwh	4.90[a]	4.65[a]	4.85[a]	4.80[a]	4.50[b]
SPNsoak	4.50[b]	3.83[c]	3.90[b]	4.65[a]	3.90[c]
SPNgerm	3.75[c]	2.21[d]	2.00[c]	3.60[c]	2.50[d]

[1] Rating scores for sensory attributes: 1- dislike very much; 2 – dislike 3 – neither likes nor dislike; 4 – like; 5 – like very much. Rating scores for overall acceptability: 1- unacceptable; 2 – acceptable only when very hungry; 3 – fairly acceptable; 4 – moderately acceptable; 5 – highly acceptable. Ratings in a column of a diet group with different superscripts are significantly different at $p < 0.05$.

[2] MZ = maize - plain, MPSr = maize - peanut - sardine, MPNwh = maize - peanut - whole *mshindi*, MPSrNwh = maize - peanut - sardine - whole *mshindi*, MPNsoak = maize - peanut - soaked *mshindi*, MPNgerm = maize - peanut - germinated *mshindi*, SG = sorghum - plain, SPSr = sorghum - peanut - sardine, SPNwh = sorghum - peanut - whole *mshindi*, SPSrNwh = sorghum - peanut - sardine - whole *mshindi*, SPNsoak = sorghum - peanut - soaked *mshindi*, SPNgerm = sorghum - peanut - germinated *mshindi*..

Table 7: Comparison of energy densities, protein-energy values and organoleptic qualities of the plain and composite maize/sorghum - *mshindi*/sardine/peanut gruels with the UN - Protein – Calorie Advisory Group (PAG) recommendations for home-made weaning mixtures (Cameron & Hofvander, 1976; Pellet & Mamabranchi, 1979)

Diet[1]	Quality Criterion				
Organoleptic	Amino acid[2] score (%)	Protein-energy (%)	(kcal)	Energy (%)	NdpE[3] quality
Maize based diets					
MZ	42	10.5	397	3.7	
Acceptable					
MPSr	65	20.2	413	6.8	Acceptable
MPNwh	79	15.1	400	6.6	Acceptable
MPSrNwh	55	21.1	404	6.3	Acceptable
MPNsoak	79	15.0	399	6.6	Acceptable
MPNgerm	78	14.8	401	6.5	Objectionable
Sorghum-based diets					
SG	37	13.4	385	4.0	Acceptable
SPSr	67	22.7	404	8.5	Acceptable
SPNwh	70	17.8	378	8.1	Acceptable
SPSrNwh	73	22.9	397	8.5	Acceptable
SPNsoak	68	17.2	392	7.9	Acceptable
SPNgerm	68	17.1	393	7.9	Objectionable
UN-PAG Recom.	> 65%	≥ 15	≥ 360	6 – 8	Acceptable

[1] MZ = maize - plain, MPSr = maize - peanut - sardine, MPNwh = maize - peanut - whole *mshindi*, MPSrNwh = maize - peanut - sardine - whole *mshindi*, MPNsoak = maize - peanut - soaked *mshindi*, MPNgerm = maize - peanut - germinated *mshindi*, SG = sorghum - plain, SPSr = sorghum - peanut - sardine, SPNwh = sorghum - peanut - whole *mshindi*, SPSrNwh = sorghum - peanut - sardine - whole *mshindi*, SPNsoak = sorghum - peanut - soaked *mshindi*, SPNgerm = sorghum - peanut - germinated *mshindi*.

[2] Amino acid score computed based on FAO/WHO/ UNU (1985) amino acid reference pattern for pre-school (2 – 5 year old) age children.

[3] Net dietary protein energy percent.